Maps of the Geographical Distribution of Macrozooplankton in the Atlantic Sector of the Southern Ocean

by Uwe Piatkowski

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Contents

Summary

Macrozooplankton samples were taken during three cruises of the FRV "Walther Herwig" into the Atlantic sector of the Southern Ocean during the austral summers of 1975/76, 1977/78 and 1980/81.

The present paper presents maps on the geographical distribution and abundance of the five most frequent macrozooplankton groups in the Southern Ocean, adult krill (Euphausia superba), other euphausiids, amphipods, chaetognaths and salps.

Zusammenfassung

Während der drei Forschungsreisen des FFS "Walther Herwig" in den atlantischen Sektor des Südpolarmeeres, die in den Südsommern 1975/76, 1977/78 und 1980/81 stattfanden, wurde ein umfangreiches Makrozooplankton-Material gesammelt.

Der vorliegende Bericht untersucht die geographische Verbreitung und relative Häufigkeit von adultem Krill (Euphausia superba), anderen Euphausiiden, Amphipoden, Chaetognathen und Salpen, die die fünf häufigsten Makrozooplankton-Gruppen im Südpolarmeer darstellen.

MAPS OF THE GEOGRAPHICAL DISTRIBUTION OF MACROZOOPLANKTON IN THE ATLANTIC SECTOR OF THE SOUTHERN OCEAN

by Uwe Piatkowski

1. Introduction

The main purpose of the German Antarctic Expeditions with FRV "Walther Herwig" into the Atlantic sector of the Southern Ocean was research on Antarctic krill (Euphausia superba) and commercial fish species.

Sahrhage et al. (1978), Hempel et al. (1979) and Hempel (1982) have reported comprehensively on the three expeditions, which took place during the austral summers of 1975/76, 1977/78 and 1980/81.

Net sampling programmes were carried out to investigate distribution and abundance of krill and to analyse population structures. Sampling gear consisted of a pelagic midwater trawl, a Bongo net and a rectangular midwater trawl (RMT 1+8) (Baker et al. 1973). The latter was used in conjunction with echo-surveys.

The krill samples obtained were studied intensively by several authors (i.g. Nast 1978, 1982a, b, Nast et al. 1982, Pommeranz 1978a, b, Siegel 1982, 1983, Wörner 1979).

Macrozooplankton groups other than krill that were examined, included other euphausiids (Weigmann-Haass and Haass 1980), amphipods (Andres 1978, 1982, 1983, Weigmann-Haass 1983), chaetognaths (James 1979), postlarval notothenioids (Kellermann and Kock 1984) and myctophids (Rowedder 1979).

This report is part of a master thesis (Piatkowski 1982). It describes the geographical distribution and abundance of the five prevailing macrozooplankton taxa caught with the RMT 8 on all three expeditions. They are krill (Euphausia superba), other euphausiids, amphipods, chaetognaths and salps. The distribution charts of Euphausia superba, shown in this study, are modified figures previously published by Pommeranz (1978), Wörner (1979), Nast (1982) and Siegel (1982).

2. Material and Methods

Samples were taken in the Atlantic sector of the Southern Ocean between 30°W and 64°W. The area surveyed was subdivided into three regions (Fig. 1):

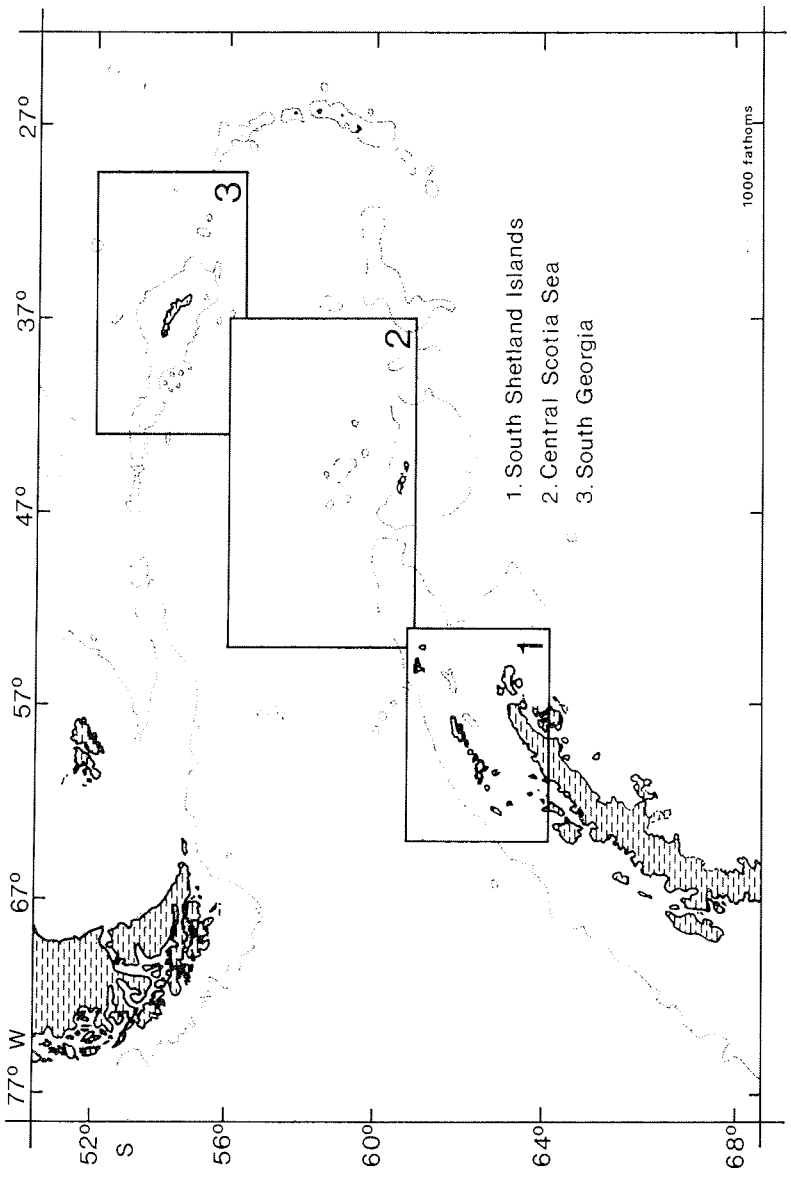

Fig. 1: Subdivisions of the area investigated.

South Shetland Islands
Central Scotia Sea
South Georgia.

All macrozooplankton samples analysed were obtained with the RMT 8 (mesh size 4.5 mm, mouth opening approximately 8 m^2) of the Institute of Oceanographic Science's RMT 1+8 (Baker et al. 1973). The standard procedure was an oblique haul in the surface waters (maximum fishing depth 200 m).

Volume of filtered water was calculated by Pommeranz (unpublished). Station maps and lists, detailed descriptions of hauls, accurate haul depths and comments on stations were published by

Wörner and Kühn (1978)	for cruise 1975/76
Wörner (1978)	for cruise 1977/78
Piatkowski and Klages (1983)	for cruise 1980/81.

Sorting procdures and results of the micronekton and zooplankton investigations were given by

James and Wörner (1978)	for cruise 1975/76
James (1980)	for cruise 1977/78
Piatkowski et al. (1984)	for cruise 1980/81.

James and Wörner (1978), assisted by several students sorted the RMT 8 samples into the following taxa:

Fish
Fish larvae
Fish eggs
Scyphomedusae
Euphausia superba (postlarvae and adults)
Other Euphausiids (postlarvae and adults)
Amphipods
Decapods (postlarvae and adults)
Mysids
Chaetognaths
Salps
Siphonophores
Polychaetes
Cephalopods
Other Molluscs
Copepods + Ostracods (presence/absence).

For this study only Euphausia superba, other euphausiids, amphipods, chaetognaths, and salps were considered for analyses of geographical distribution and abundance, as they were clearly the most abundant macrozooplankton groups.

3. Results

A total of 357 samples was analysed in this study. In Table 1 they are compiled according to geographical locations and time of year.

Composition of macrozooplankton groups

Euphausia superba was the prevailing macrozooplankton species in all three areas surveyed. Other euphausiids found, were mainly Thysanoessa macrura, E. frigida and E. triacantha, of which T. macrura was the most abundant euphausiid next to E. superba. The major representative amphipod was the hyperiid Themisto gaudichaudii. Of the chaetognaths, the species Eukrohnia hamata and Sagitta gazellae prevailed. Salpa thompsoni was the absolute dominant species of the salps.

Geographical distribution and abundance

Table 2 presents the density classes, in which the major macrozooplankton taxa occurred. Only E. superba and salps were found in densities higher than 10000 ind/m^2.

Maximum concentrations of different macrozooplankton groups in each of the three regions are shown in Table 3:

Table 3 Maximum concentrations of different macrozooplankton groups in the three regions investigated (individuals/m^2).

Group	South Shetland Islands	Central Scotia Sea	South Georgia
Euphausia superba	7766	1727	333746
Other euphausiids	1074	143	667
Amphipods	168	380	505
Chaetognaths	97	511	1053
Salps	36033	41520	1896

Figures 2 - 81 show the geographical distribution and abundance of the predominant taxa in the three regions investigated.

Each figure represents a different month and cruise leg, thus monthly and annual differences in the distribution and abundance of the macrozooplankton groups in each of the three regions become apparent.

Table 1 Number of analysed RMT 8 samples compiled according to geographical locations and time of year.

Location	November	December	January	February	March	April	Total
South Shetland Islands							
Cruise 1975/76	-	-	4	17	-	-	21
Cruise 1977/78	27	12	16	8	42	-	105
Cruise 1980/81	-	-	3	6	23	-	32
Central Scotia Sea							
Cruise 1975/76	4	20	1	11	7	-	43
Cruise 1977/78	7	7	9	5	6	-	34
Cruise 1980/81	-	-	-	24	-	-	24
South Georgia							
Cruise 1975/76	-	34	-	-	1	7	42
Cruise 1977/78	16	8	9	-	17	6	56
Cruise 1980/81	-	-	-	-	-	-	-

Table 2 Number and percentage of catches separated in major macrozooplankton taxa and grouped in density classes.

Density class Individuals/m^2	Euphausia superba number	%	Other euphausiids number	%	Amphipods number	%	Chaetognaths number	%	Salps number	%
⩽ 0.1	59	22.5	19	5.8	57	17.2	51	17.3	33	13.9
0.1 - 1	87	33.2	84	25.5	120	36.3	120	40.7	64	26.9
1.1 - 10	47	17.9	141	42.7	113	34.1	105	35.6	66	27.7
11 - 100	44	16.8	74	22.4	34	10.3	16	5.4	41	17.2
101 - 1000	17	6.5	11	3.3	7	2.1	2	0.7	19	8.0
1001 - 10000	6	2.3	1	0.3	0	0	1	0.3	11	4.6
⩾ 10000	2	0.8	0	0	0	0	0	0	4	1.7
Positive catches	262	74.3	330	92.0	331	92.8	295	82.7	238	67.2
Zero catches	95	25.7	27	8.0	26	7.2	62	17.3	119	32.8
Total	357	100.0	357	100.0	357	100.0	357	100.0	357	100.0

Particularly rich samples of Euphausia superba ($\geqslant$ 1000 ind/m^2) were found in the waters off Elephant Island, in the northwestern part of the Weddell Sea and on the northern shelf regions of South Georgia. In November/December krill concentrations were significantly higher than in the following months. E. superba distribution was heterogeneous. Apart from maximum concentrations of all groups investigated E. superba also showed the highest number of samples with densities less than 0.1 ind/m^2.

Other euphausiids, amphipods and chaetognaths occurred in distinctly lower numbers than E. superba and salps. They had a more even distribution than E. superba in all areas investigated. Annual or monthly differences in abundance could not be detected.

Highest concentrations of salps were obtained during January and February in all regions. The numbers caught were significantly high, if E. superba occurred in low densities (Figs. 36 and 56, 57 and 77).

Comparing the abundances of different times of the day only salps indicated patterns of a diurnal migration, because their numbers increased in the surface waters during the hauls at dusk.

The data did not reveal a significant diurnal migration of the other groups, these appeared to remain within the surface layers ($\leqslant$ 200 m water depth) both during the day and night (Table 4).

Table 4 Mean abundances of investigated macrozooplankton groups (individuals/m^2) at various times of the day. DA = daytime, DU = dusk, NI = nighttime, DW = dawn.

Group	DA	DU	NI	DW
Euphausia superba	1426	21	519	74
Other euphausiids	20	10	15	14
Amphipods	11	5	6	2
Chaetognaths	10	$\leqslant$ 1	2	1
Salps	492	2188	127	11

The abundance of all five groups, especially that of the salps was significantly higher in the season of 1975/76 than in the seasons of 1977/78 and 1980/81, which is applicable to all three regions investigated.

Acknowledgements

I thank all scientists as well as the crew of the FRV "Walther Herwig", who were engaged in the plankton sampling programmes during the three cruises. I am grateful to the many colleagues, who carefully sorted the numerous plankton samples. Dr. T. Pommeranz kindly supplied his unpublished data of the filtered water volumes of the RMT 8. Thanks are due to Dr. G. Dieckmann for his help in correcting the English and to Mrs. S. Marschall for typing the draft.

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5. Maps of Macrozooplankton Distribution

South Shetland Islands

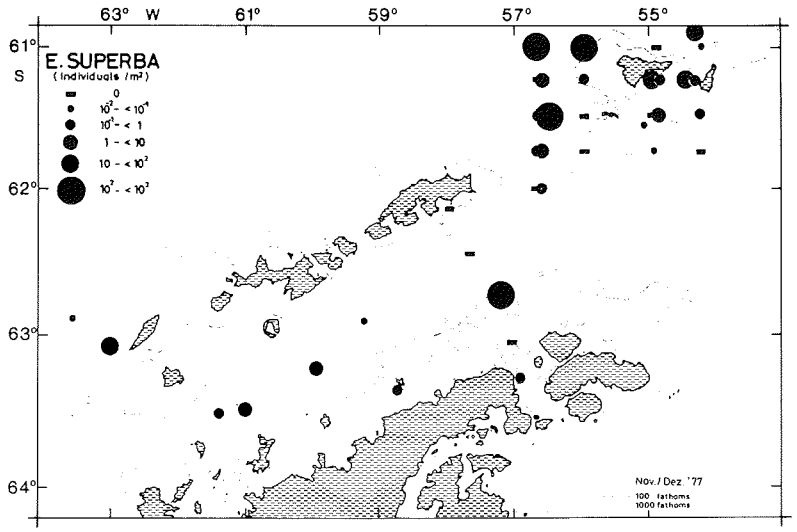

Fig. 2: Geographical distribution and relative abundance of Euphausia superba by RMT 8 samples in November/December 1977 (modified from Wörner 1979).

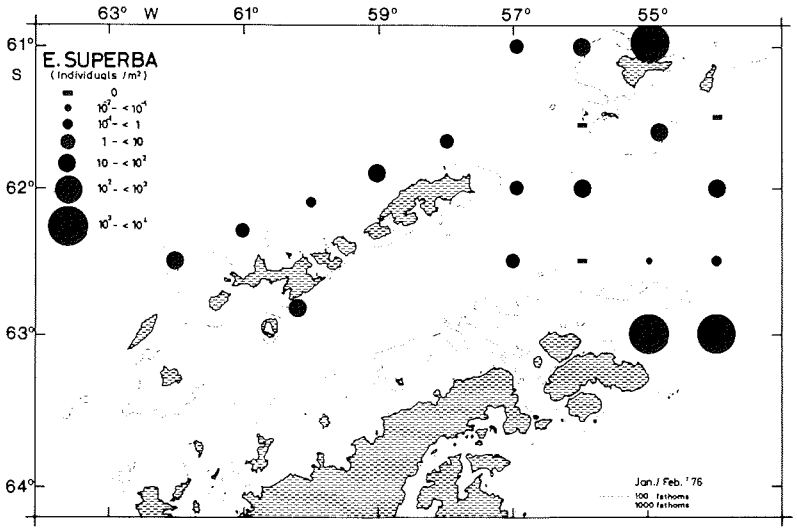

Fig. 3: Geographical distribution and relative abundance of Euphausia superba by RMT 8 samples in January/February 1976 (modified from Pommeranz 1978).

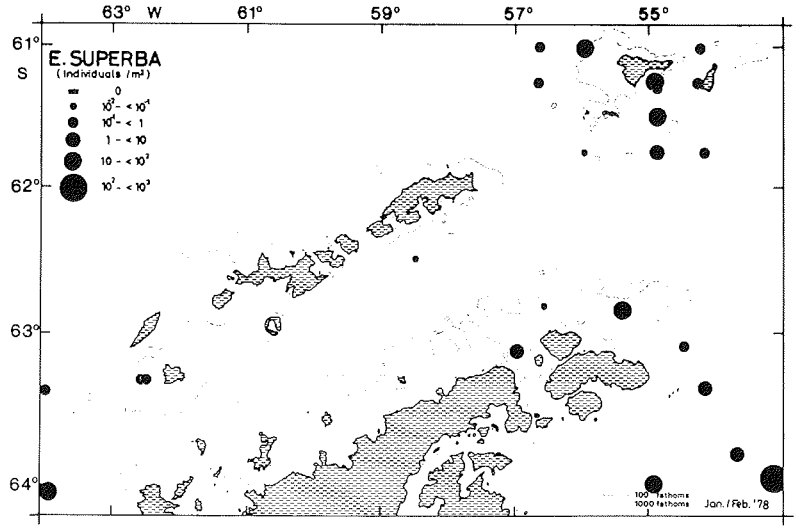

Fig. 4: Geographical distribution and relative abundance of Euphausia superba by RMT 8 samples in January/February 1978 (modified from Wörner 1979).

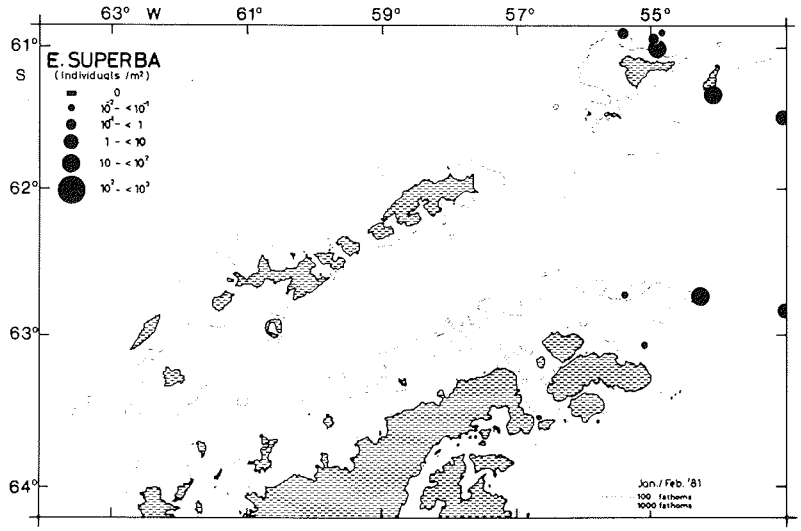

Fig. 5: Geographical distribution and relative abundance of Euphausia superba by RMT 8 samples in January/February 1981 (modified from Nast 1982b).

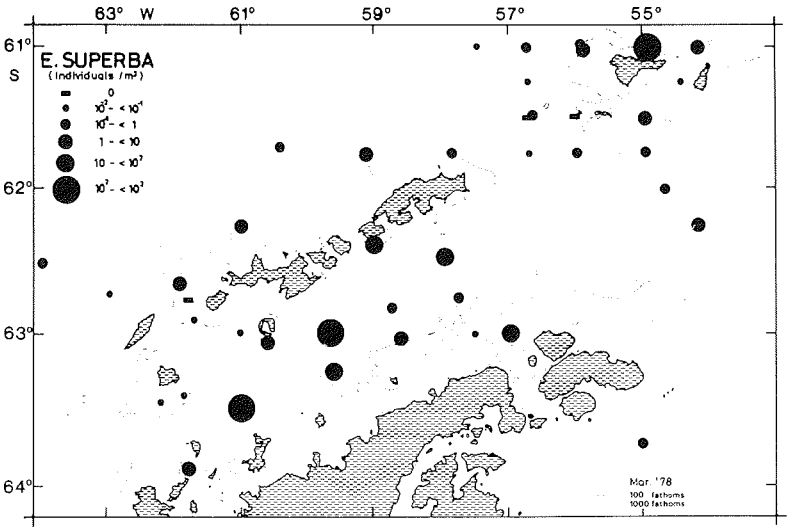

Fig. 6: Geographical distribution and relative abundance of Euphausia superba by RMT 8 samples in March 1978 (modified from Wörner 1979).

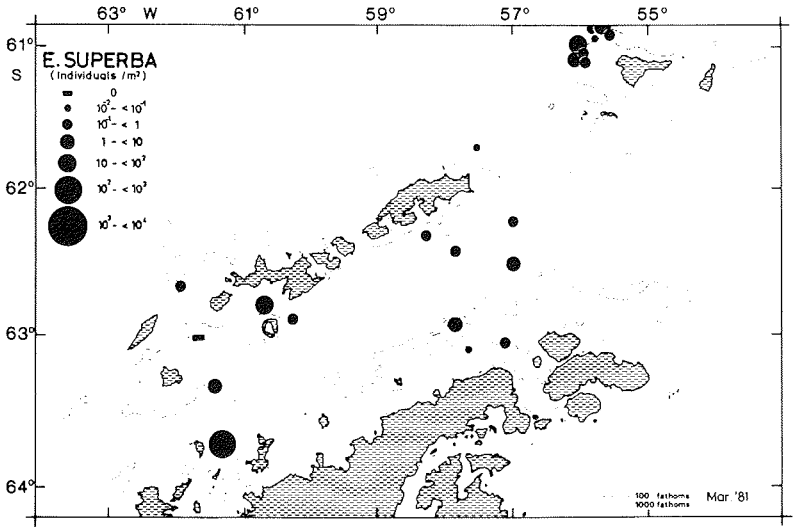

Fig. 7: Geographical distribution and relative abundance of Euphausia superba by RMT 8 samples in March 1981 (modified from Siegel 1982).

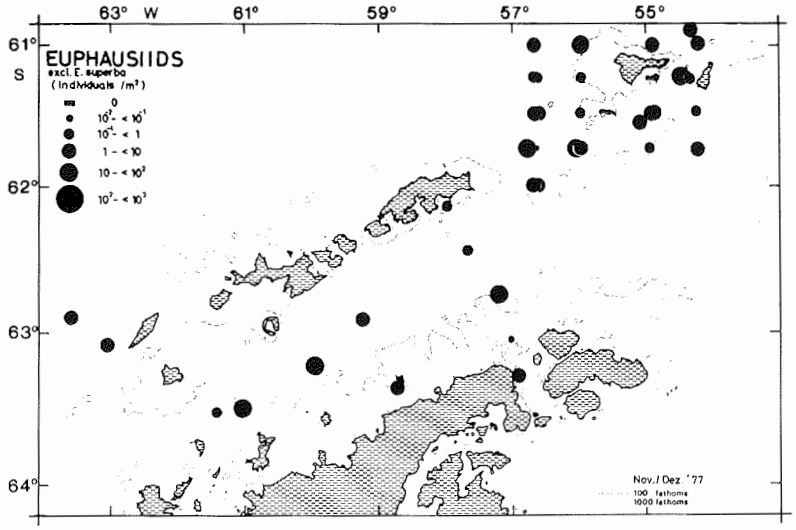

Fig. 8: Geographical distribution and relative abundance of euphausiids (excl. Euphausia superba) by RMT 8 samples in November/December 1977.

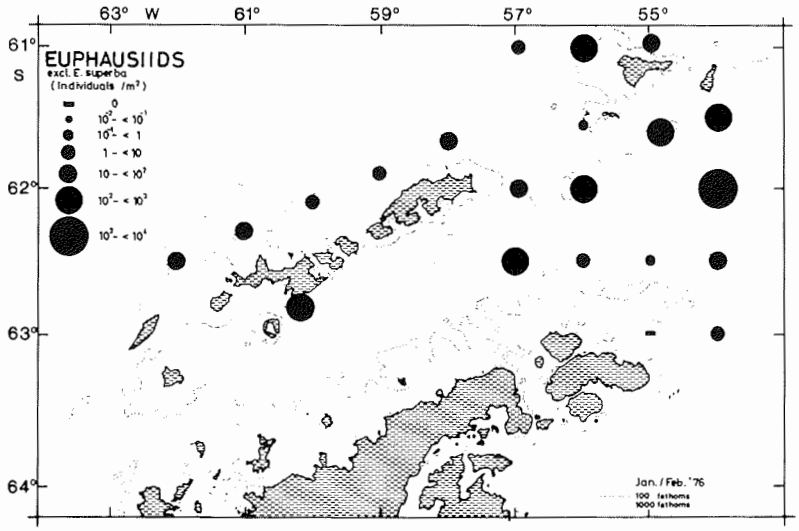

Fig. 9: Geographical distribution and relative abundance of euphausiids (excl. Euphausia superba) by RMT 8 samples in January/February 1976.

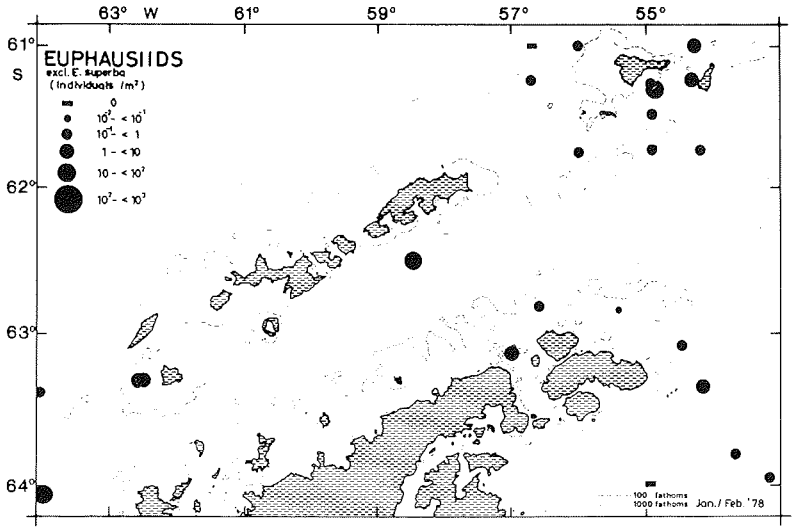

Fig. 10: Geographical distribution and relative abundance of euphausiids (excl. Euphausia superba) by RMT 8 samples in January/February 1978.

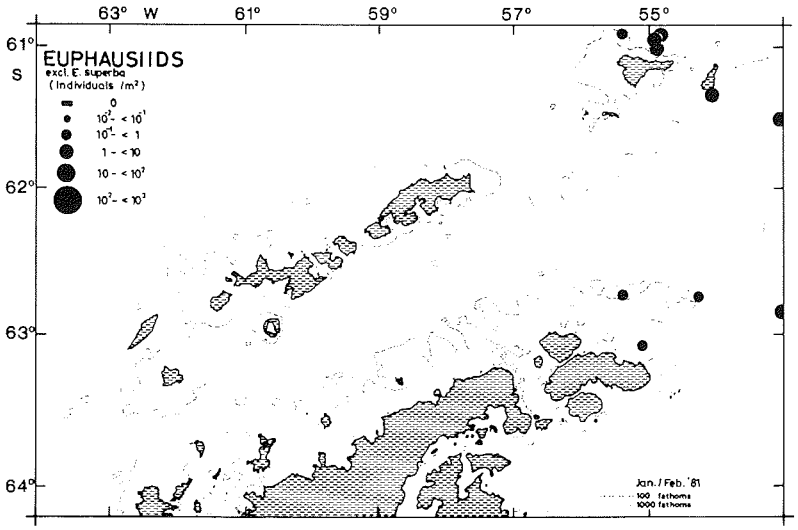

Fig. 11: Geographical distribution and relative abundance of euphausiids (excl. Euphausia superba) by RMT 8 samples in January/February 1981.

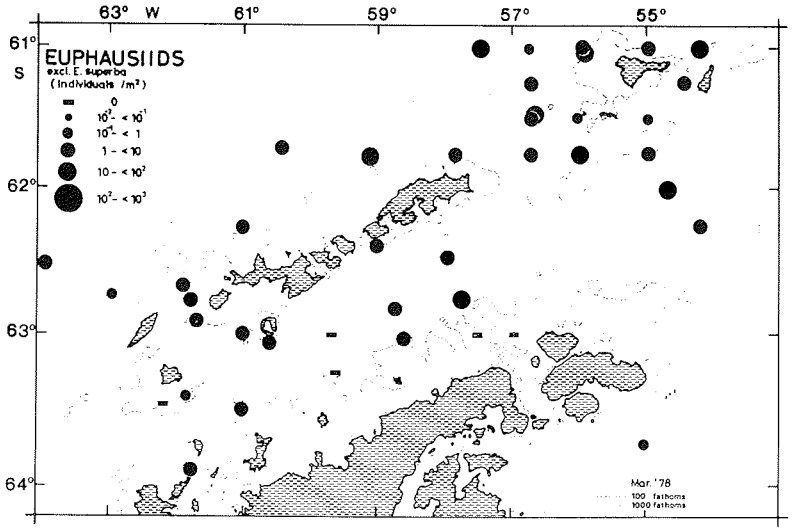

Fig. 12: Geographical distribution and relative abundance of euphausiids (excl. Euphausia superba) by RMT 8 samples in March 1978.

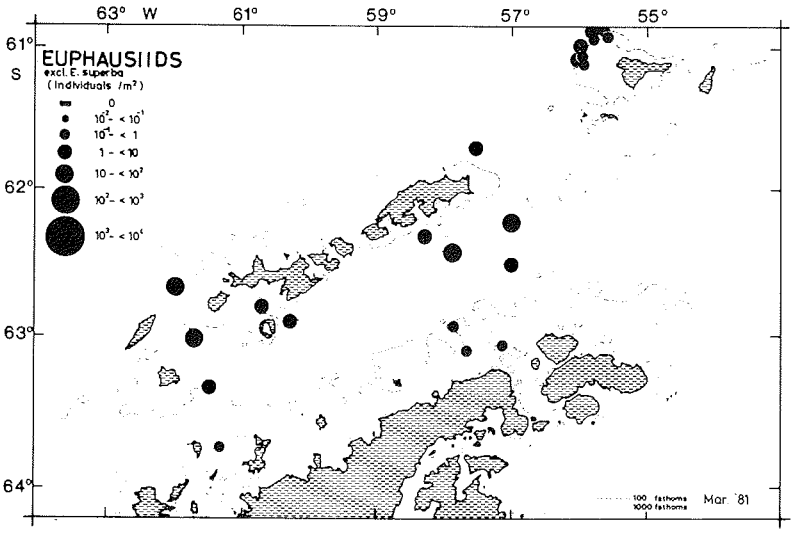

Fig. 13: Geographical distribution and relative abundance of euphausiids (excl. Euphausia superba) by RMT 8 samples in March 1981.

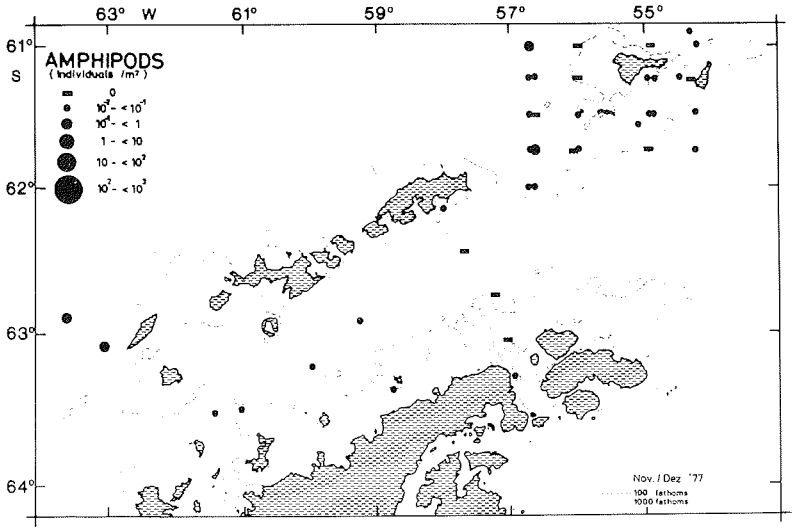

Fig. 14: Geographical distribution and relative abundance of amphipods by RMT 8 samples in November/December 1977.

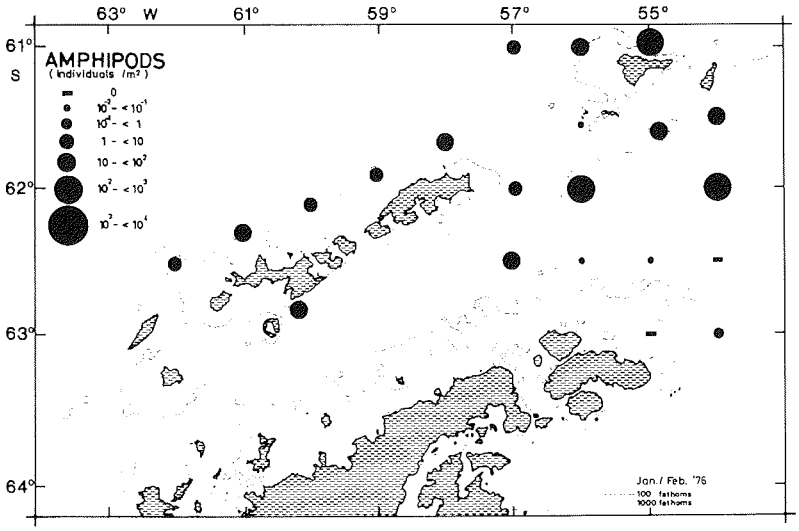

Fig. 15: Geographical distribution and relative abundance of amphipods by RMT 8 samples in January/February 1976.

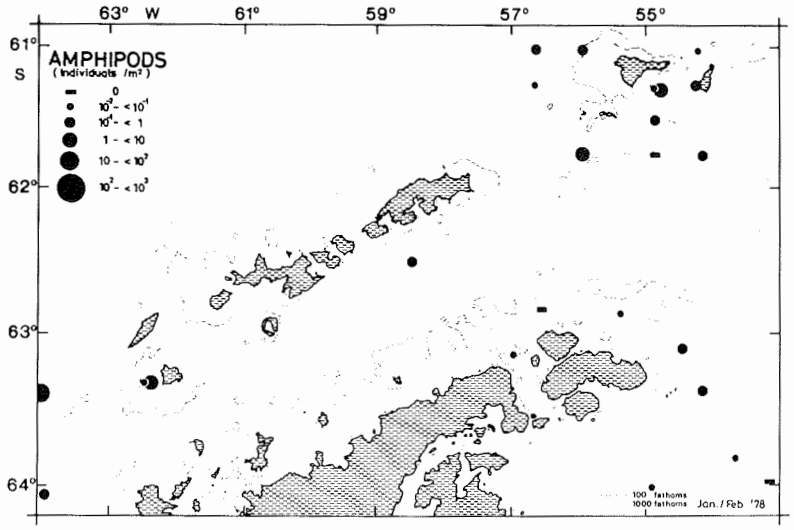

Fig. 16: Geographical distribution and relative abundance of amphipods by RMT 8 samples in January/February 1978.

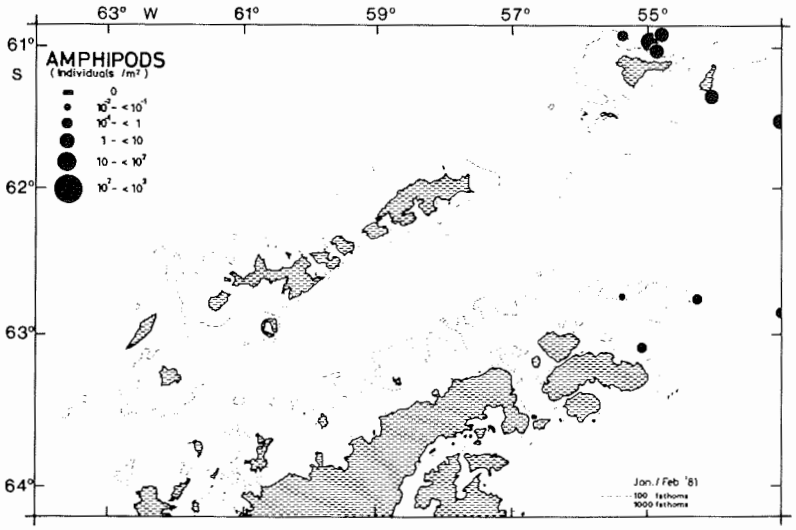

Fig. 17: Geographical distribution and relative abundance of amphipods by RMT 8 samples in January/February 1981.

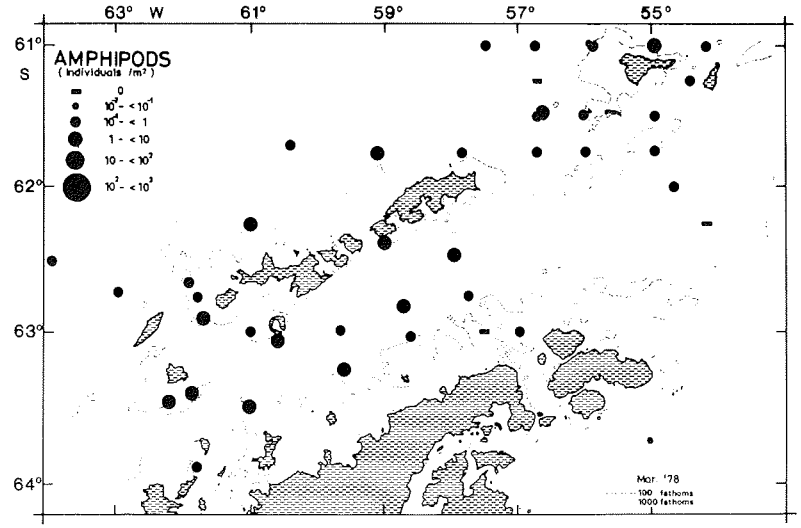

Fig. 18: Geographical distribution and relative abundance of amphipods by RMT 8 samples in March 1978.

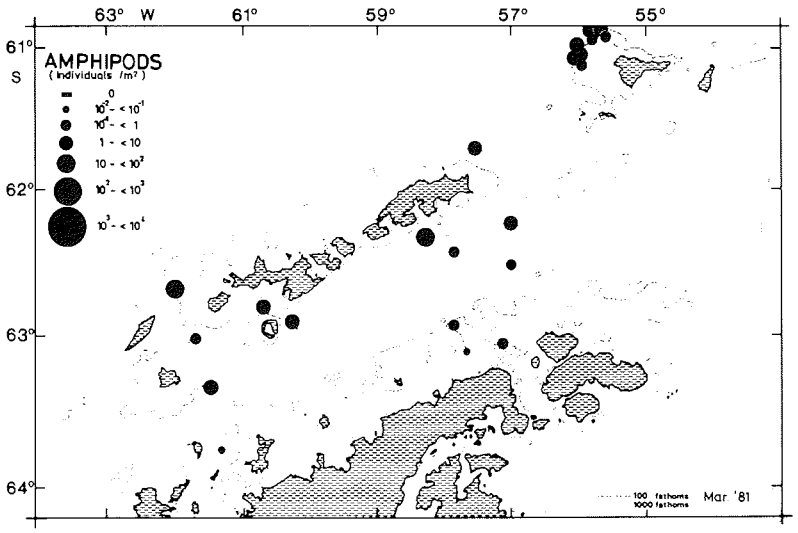

Fig. 19: Geographical distribution and relative abundance of amphipods by RMT 8 samples in March 1981.

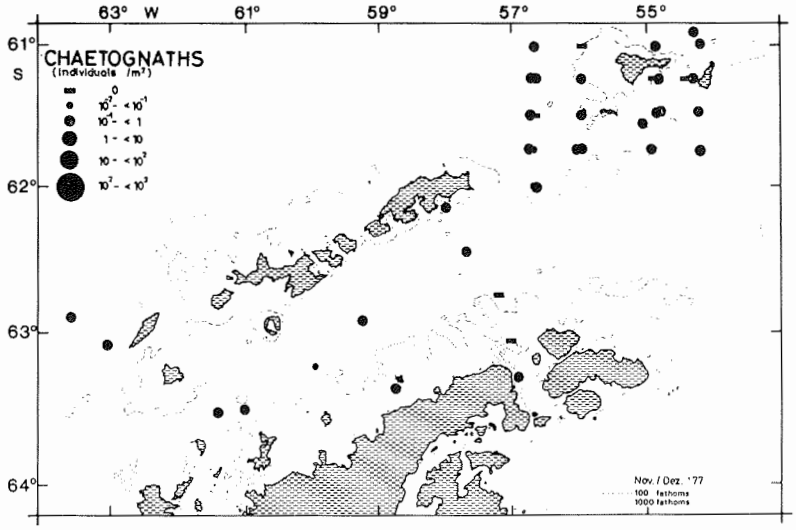

Fig. 20: Geographical distribution and relative abundance of chaetognaths by RMT 8 samples in November/December 1977.

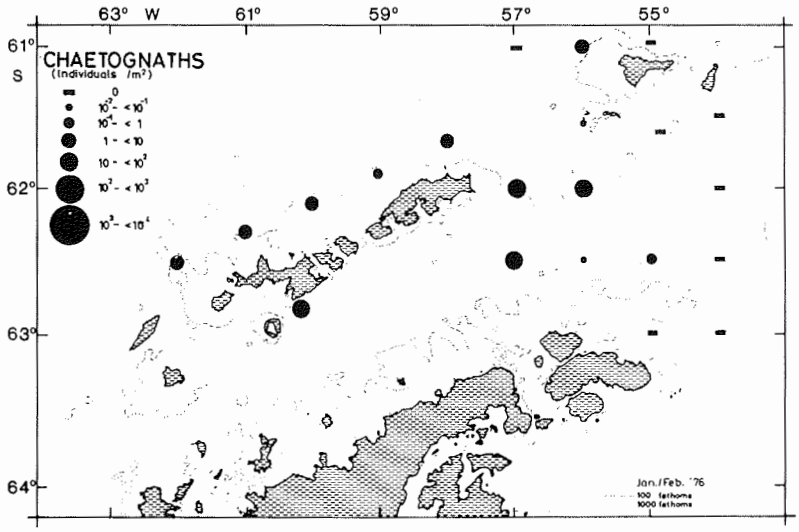

Fig. 21: Geographical distribution and relative abundance of chaetognaths by RMT 8 samples in January/February 1976.

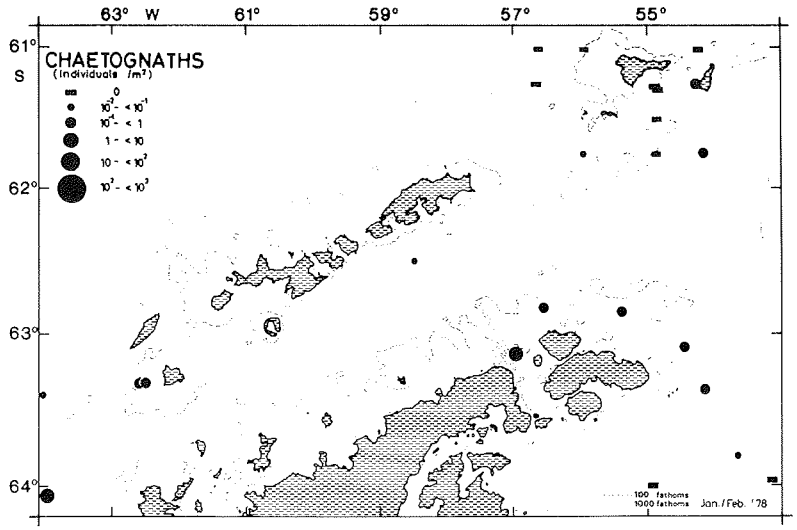

Fig. 22: Geographical distribution and relative abundance of chaetognaths by RMT 8 samples in January/February 1978.

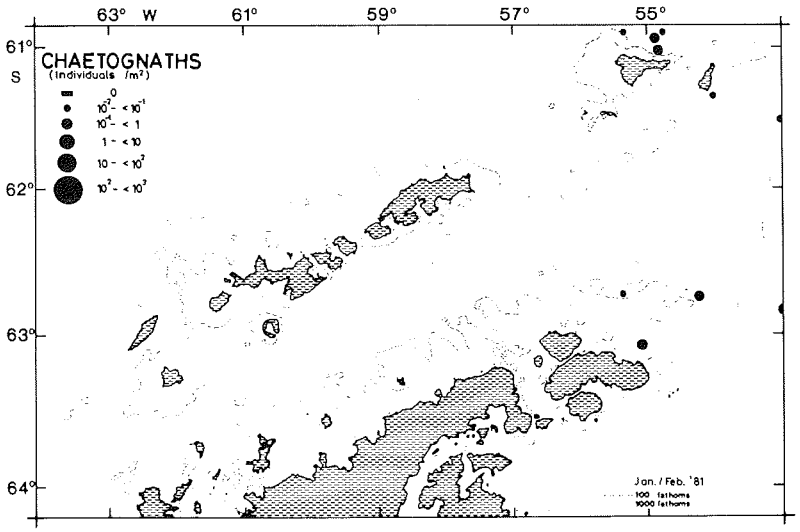

Fig. 23: Geographical distribution and relative abundance of chaetognaths by RMT 8 samples in January/February 1981.

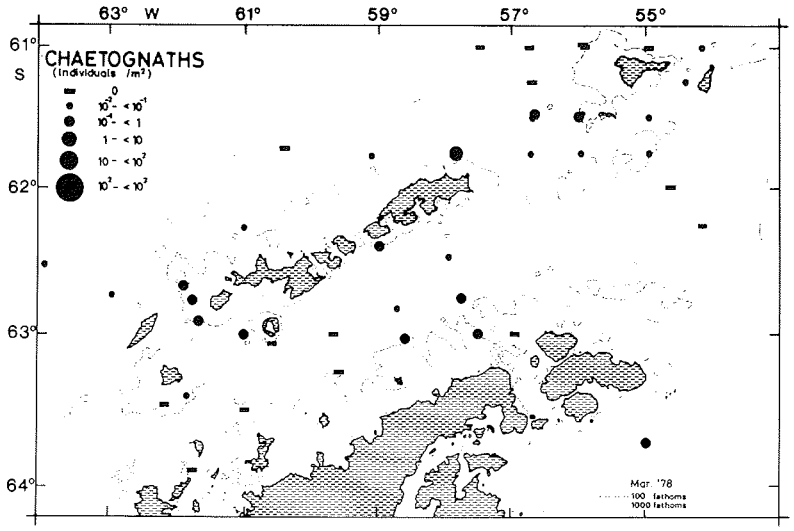

Fig. 24: Geographical distribution and relative abundance of chaetognaths by RMT 8 samples in March 1978.

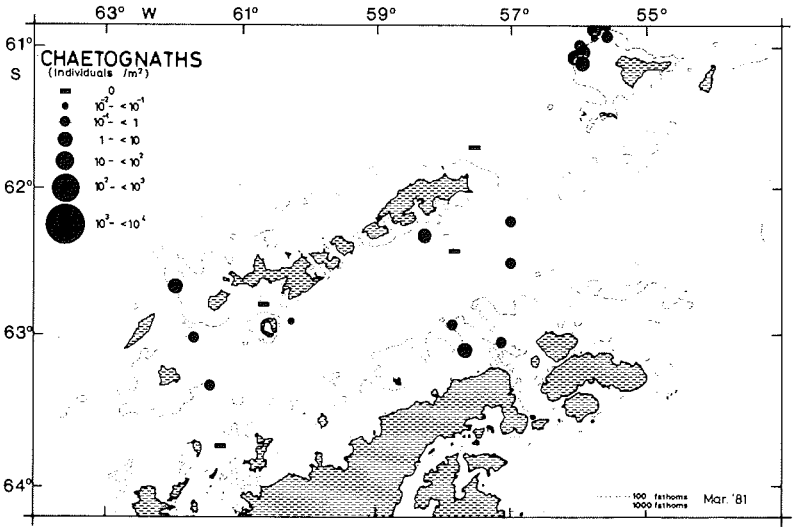

Fig. 25: Geographical distribution and relative abundance of chaetognaths by RMT 8 samples in March 1981.

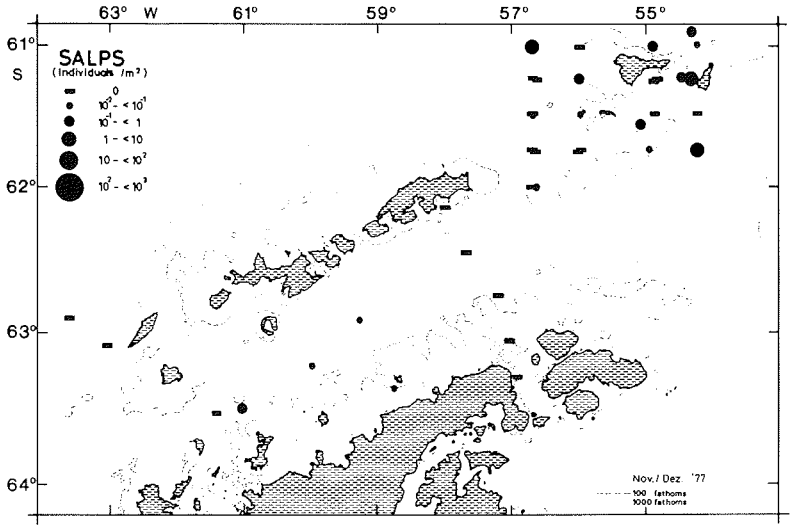

Fig. 26: Geographical distribution and relative abundance of salps by RMT 8 samples in November/December 1977.

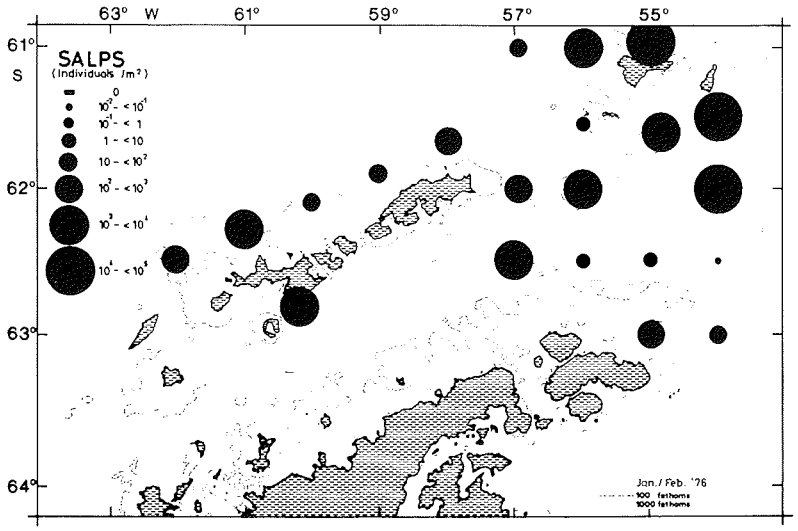

Fig. 27: Geographical distribution and relative abundance of salps by RMT 8 samples in January/February 1976.

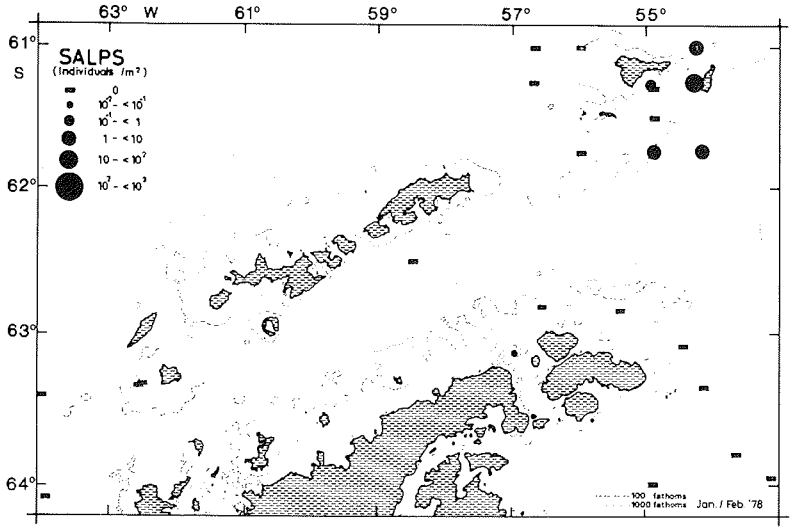

Fig. 28: Geographical distribution and relative abundance of salps by RMT 8 samples in January/February 1978.

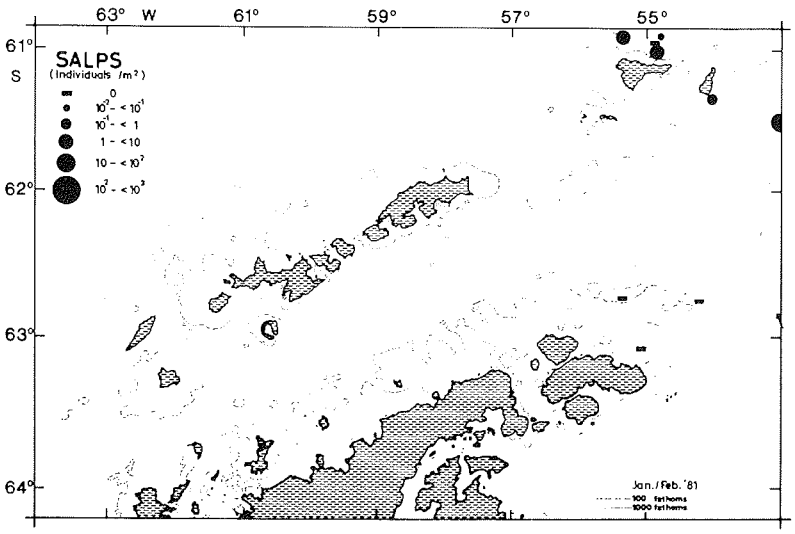

Fig. 29: Geographical distribution and relative abundance of salps by RMT 8 samples in January/February 1981.

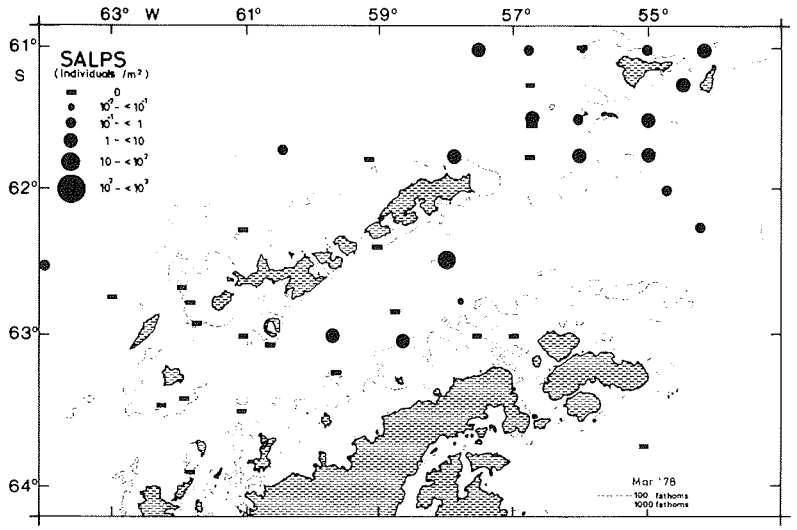

Fig. 30: Geographical distribution and relative abundance of salps by RMT 8 samples in March 1978.

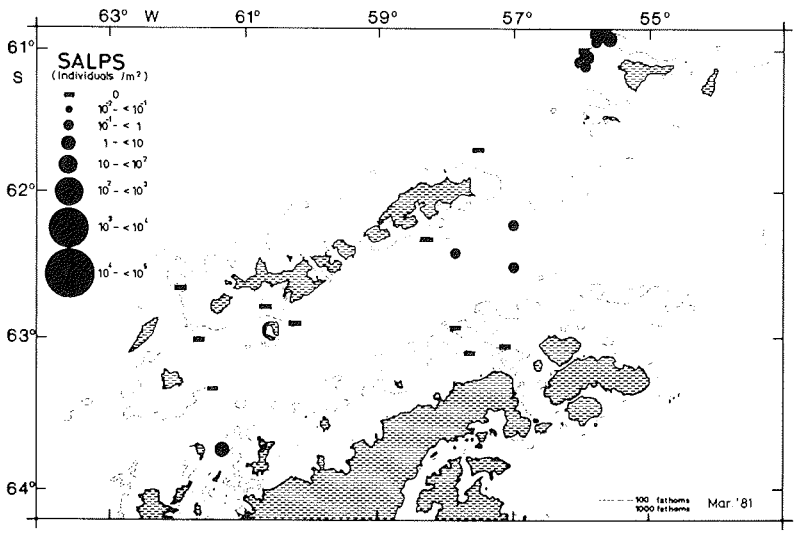

Fig. 31: Geographical distribution and relative abundance of salps by RMT 8 samples in March 1981.

Central Scotia Sea

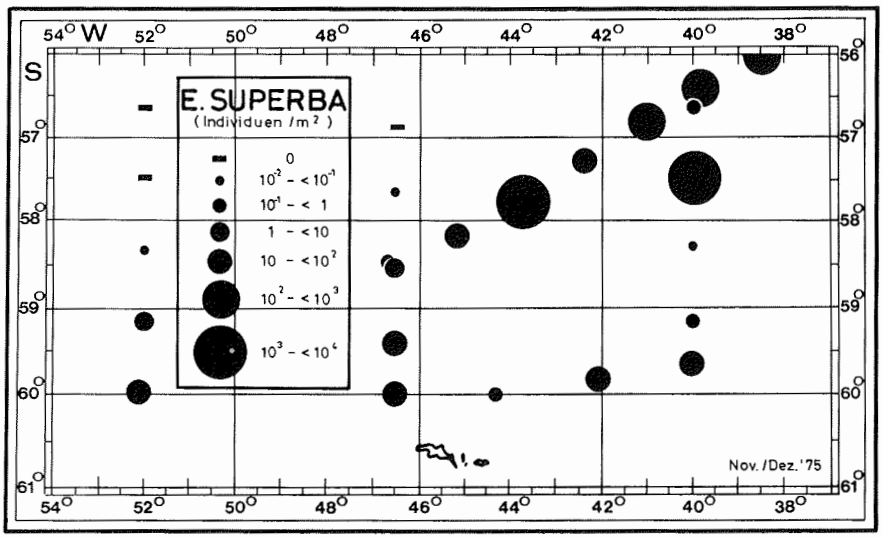

Fig. 32: Geographical distribution and relative abundance of Euphausia superba by RMT 8 samples in November/December 1975 (modified from Pommeranz 1978).

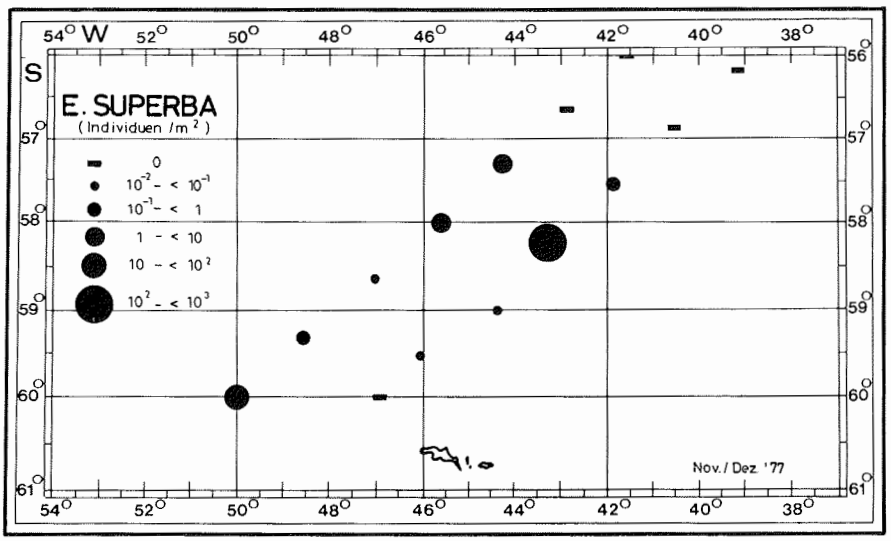

Fig. 33: Geographical distribution and relative abundance of Euphausia superba by RMT 8 samples in November/December 1977 (modified from Wörner 1979).

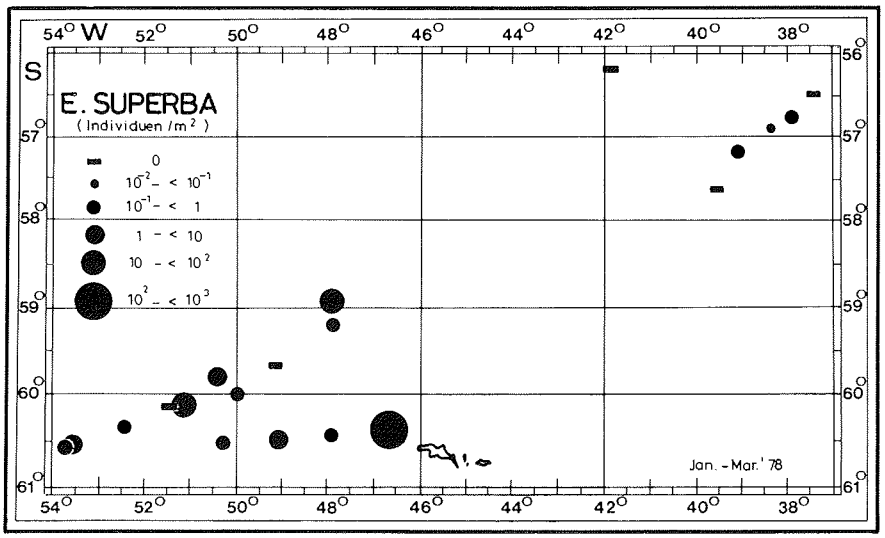

Fig. 34: Geographical distribution and relative abundance of Euphausia superba by RMT 8 samples from January to March 1978 (modified from Wörner 1979).

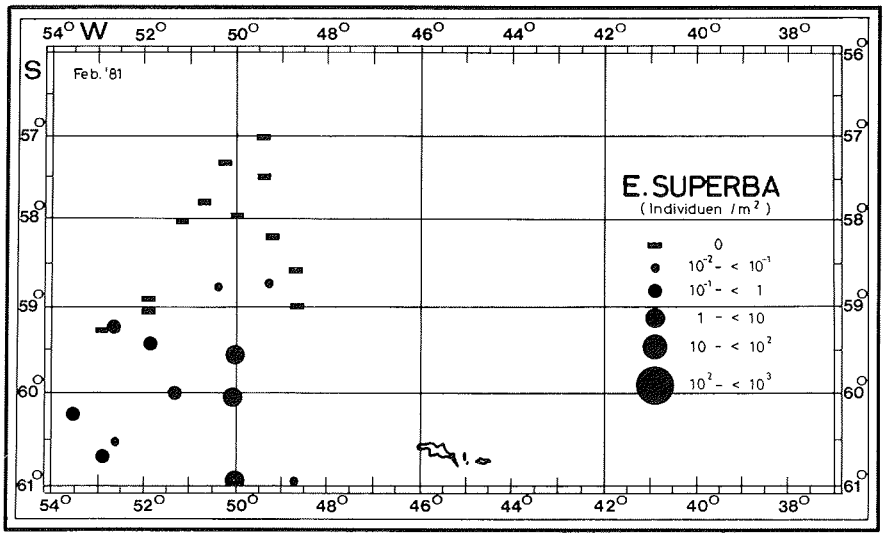

Fig. 35: Geographical distribution and relative abundance of Euphausia superba by RMT 8 samples in February 1981 (modified from Nast 1982b).

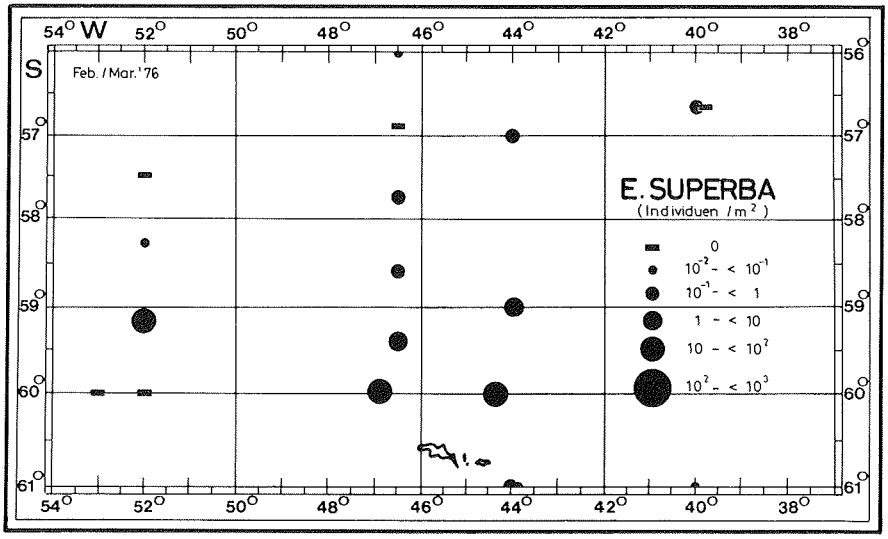

Fig. 36: Geographical distribution and relative abundance of Euphausia superba by RMT 8 samples in February/March 1976 (modified from Pommeranz 1978).

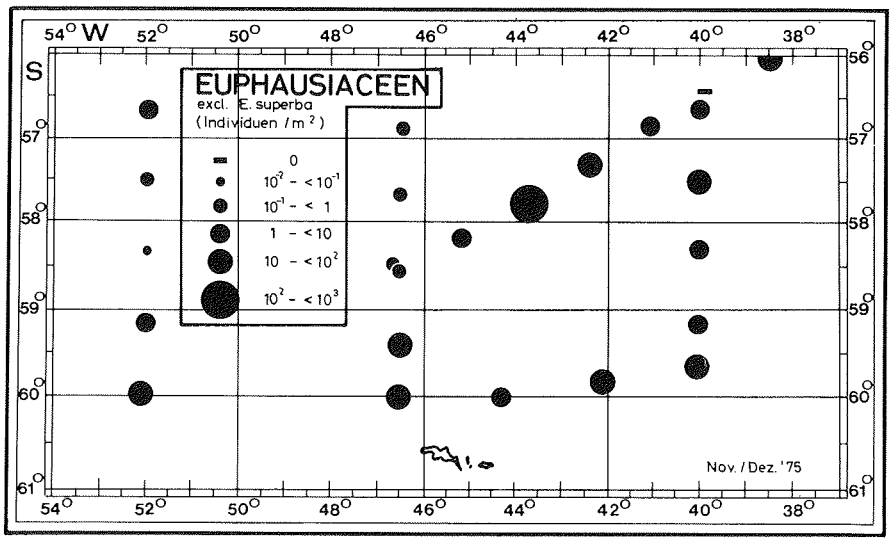

Fig. 37: Geographical distribution and relative abundance of euphausiids (excl. Euphausia superba) by RMT 8 samples in November/December 1975.

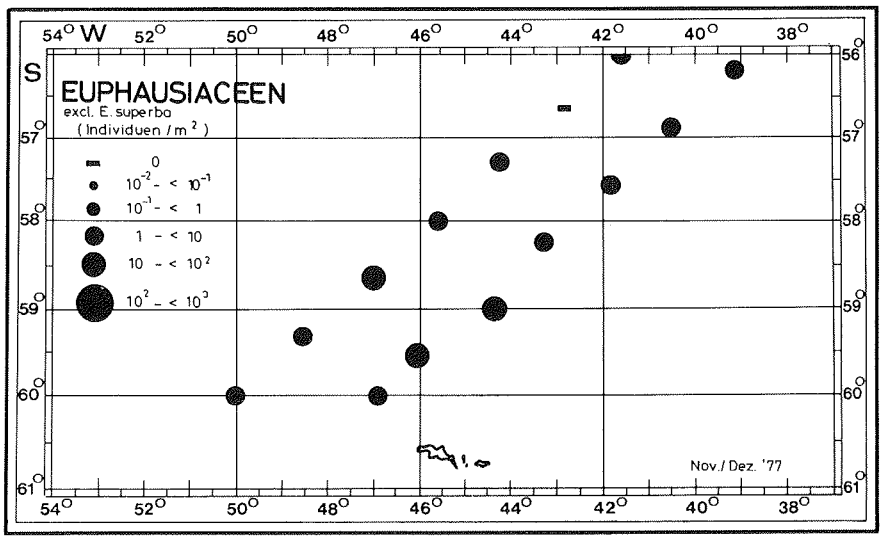

Fig. 38: Geographical distribution and relative abundance of euphausiids (excl. Euphausia superba) by RMT 8 samples in November/December 1977.

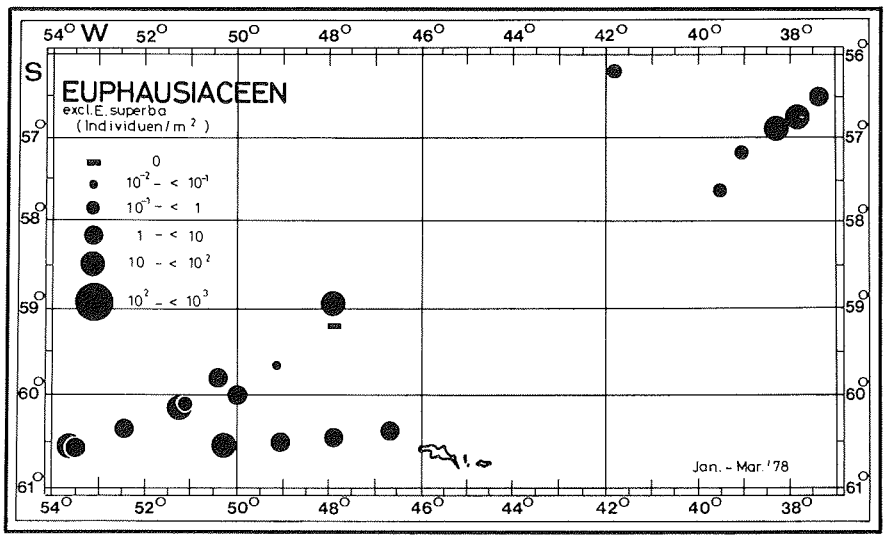

Fig. 39: Geographical distribution and relative abundance of euphausiids (excl. Euphausia superba) by RMT 8 samples from January to March 1978.

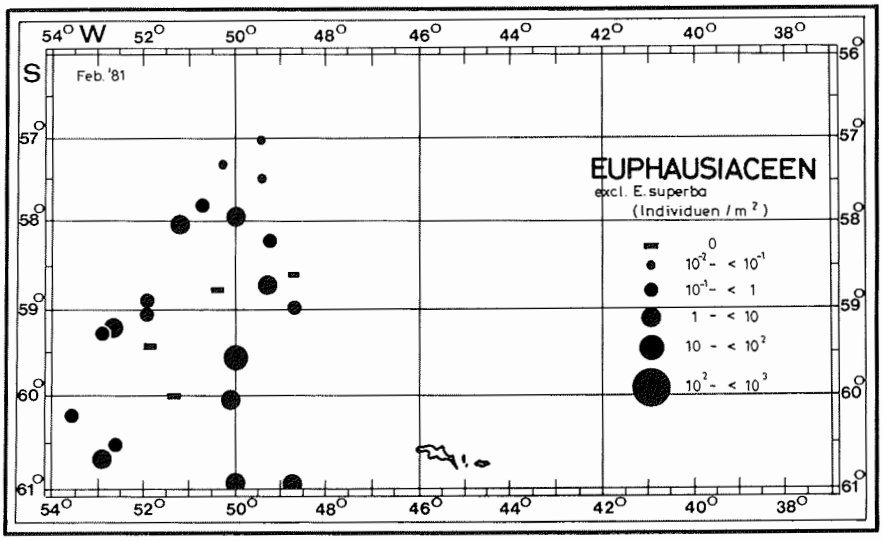

Fig. 40: Geographical distribution and relative abundance of euphausiids (excl. Euphausia superba) by RMT 8 samples in February 1981.

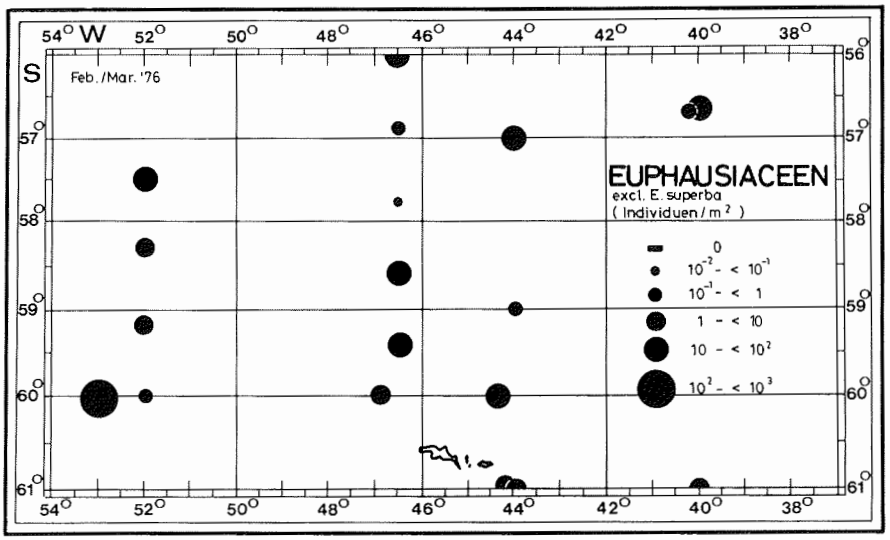

Fig. 41: Geographical distribution and relative abundance of euphausiids (excl. Euphausia superba) by RMT 8 samples in February/March 1976.

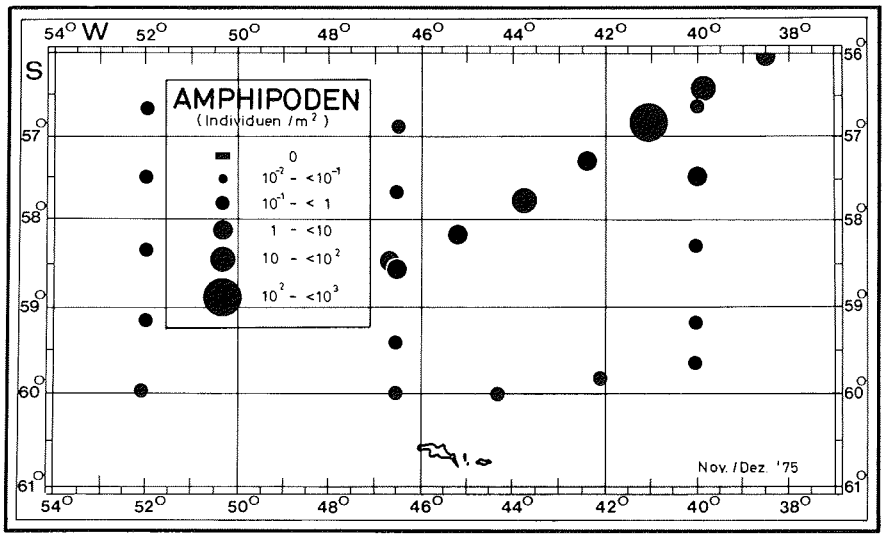

Fig. 42: Geographical distribution and relative abundance of amphipods by RMT 8 samples in November/December 1975.

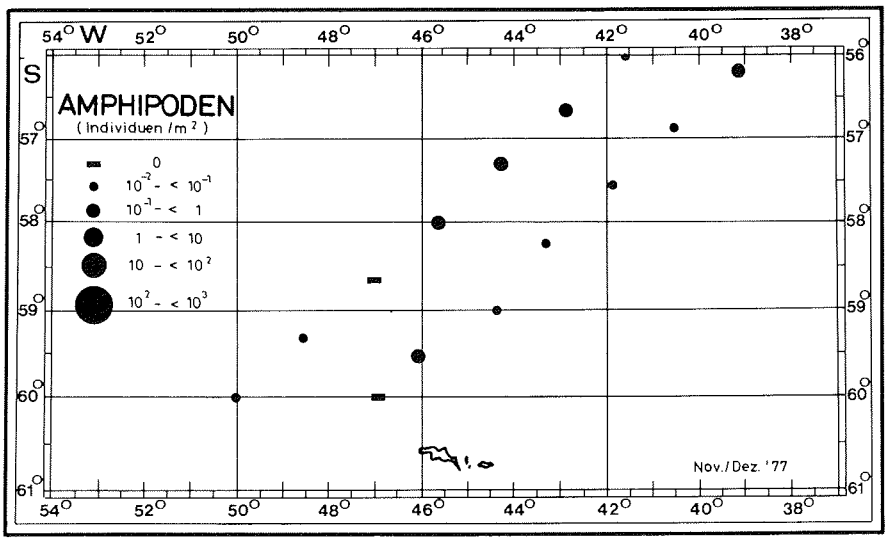

Fig. 43: Geographical distribution and relative abundance of amphipods by RMT 8 samples in November/December 1977.

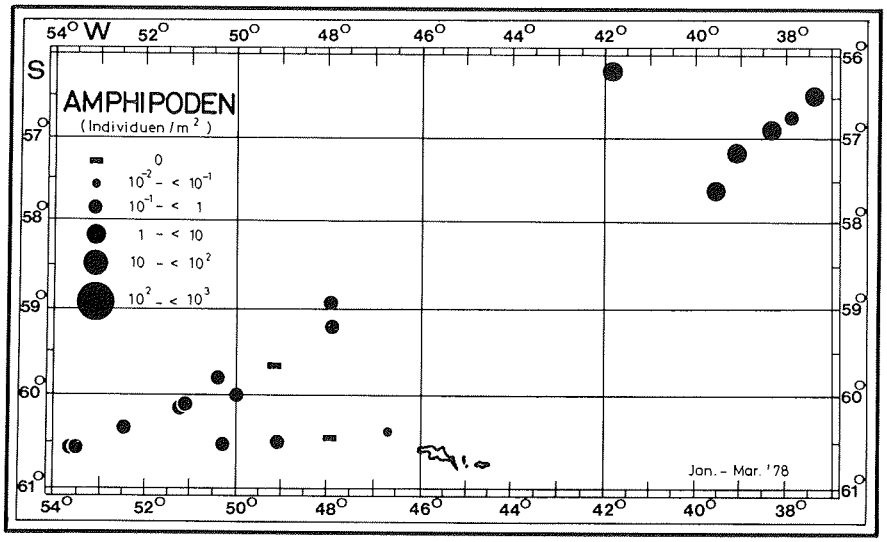

Fig. 44: Geographical distribution and relative abundance of amphipods by RMT 8 samples from January to March 1978.

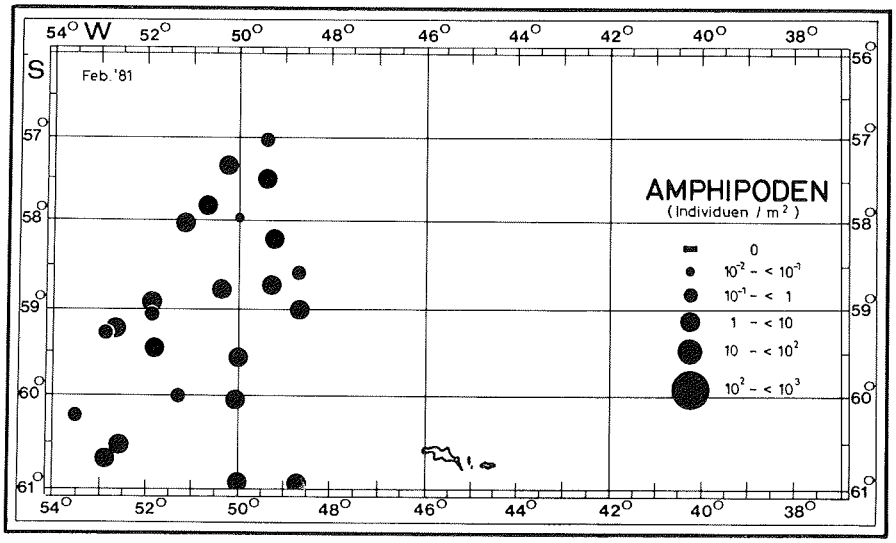

Fig. 45: Geographical distribution and relative abundance of amphipods by RMT 8 samples in February 1981.

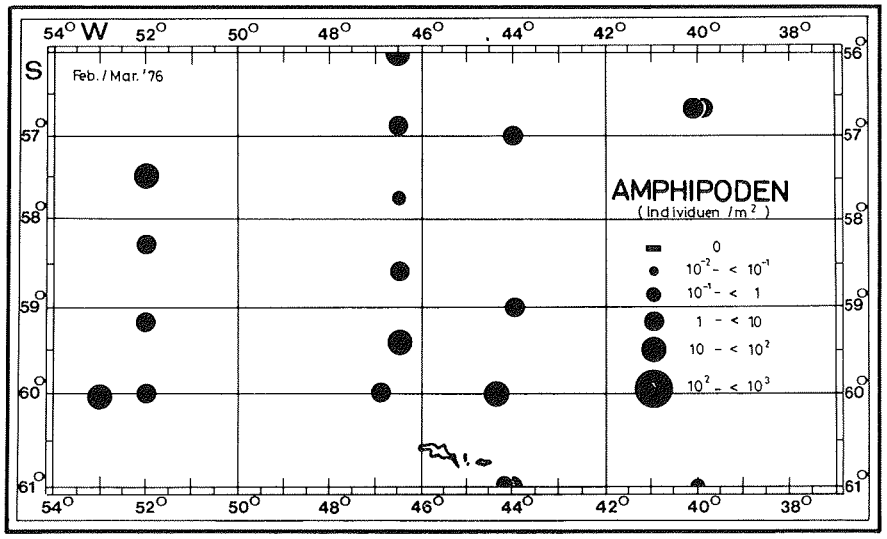

Fig. 46: Geographical distribution and relative abundance of amphipods by RMT 8 samples in February/March 1976.

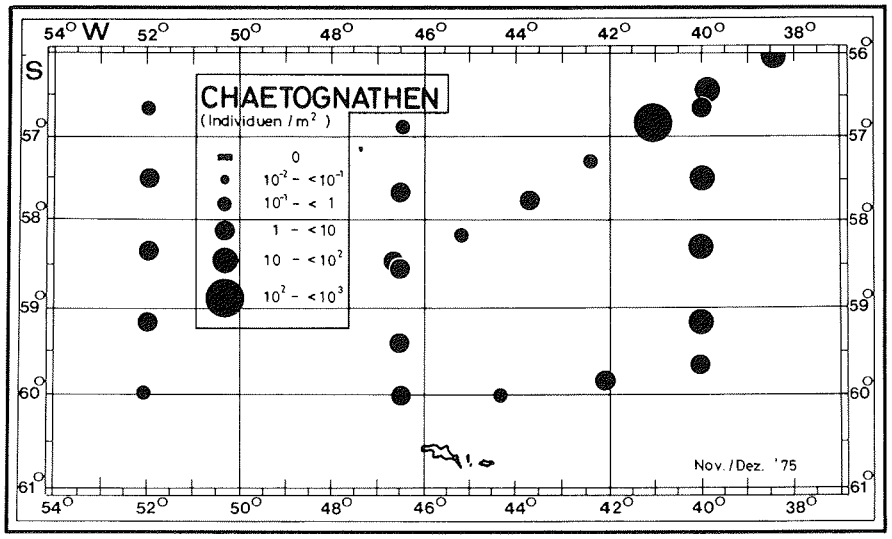

Fig. 47: Geographical distribution and relative abundance of chaetognaths by RMT 8 samples in November/December 1975.

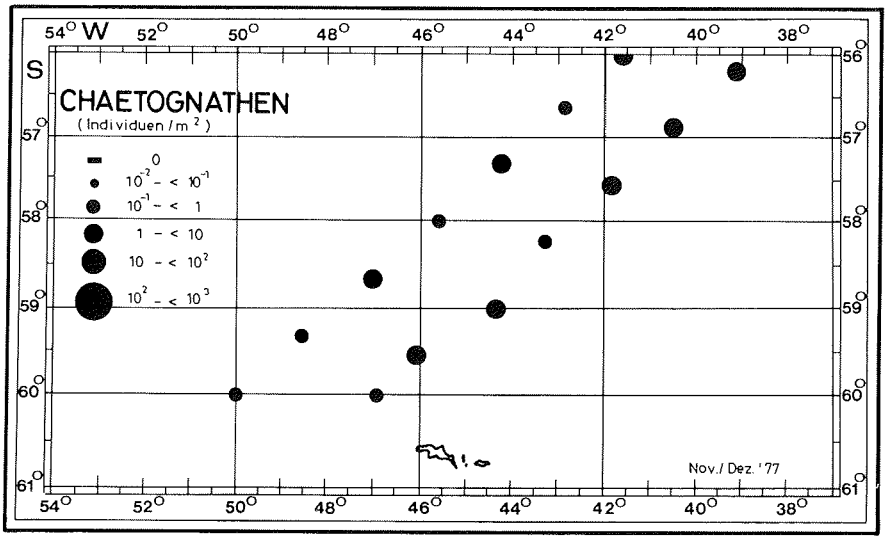

Fig. 48: Geographical distribution and relative abundance of chaetognaths by RMT 8 samples in November/December 1977.

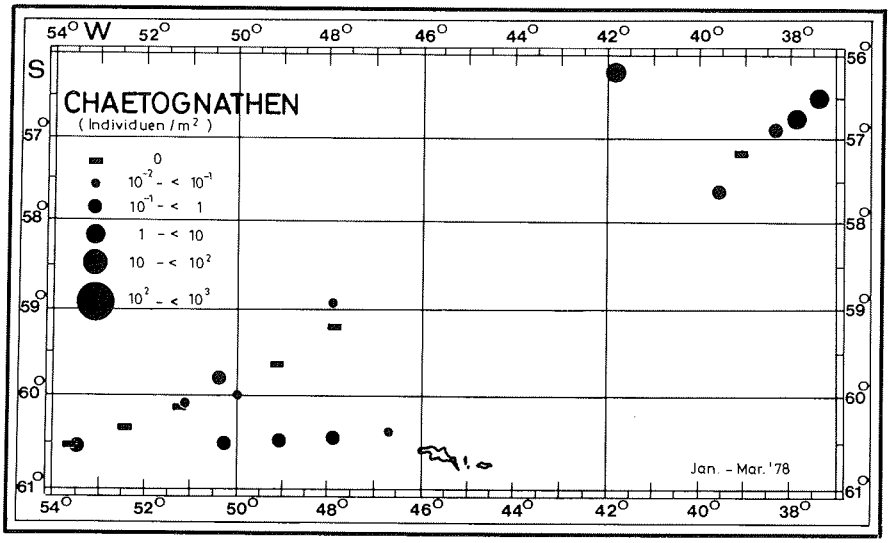

Fig. 49: Geographical distribution and relative abundance of chaetognaths by RMT 8 samples from January to March 1978.

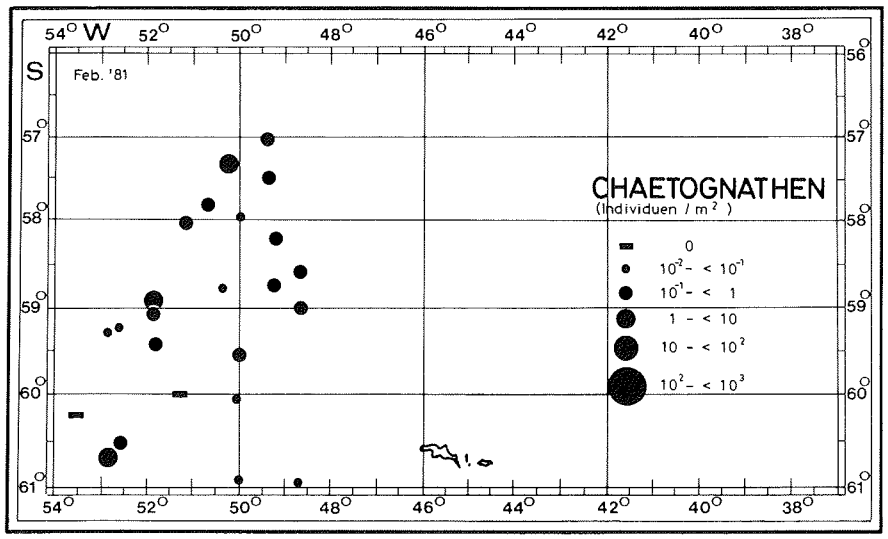

Fig. 50: Geographical distribution and relative abundance of chaetognaths by RMT 8 samples in February 1981.

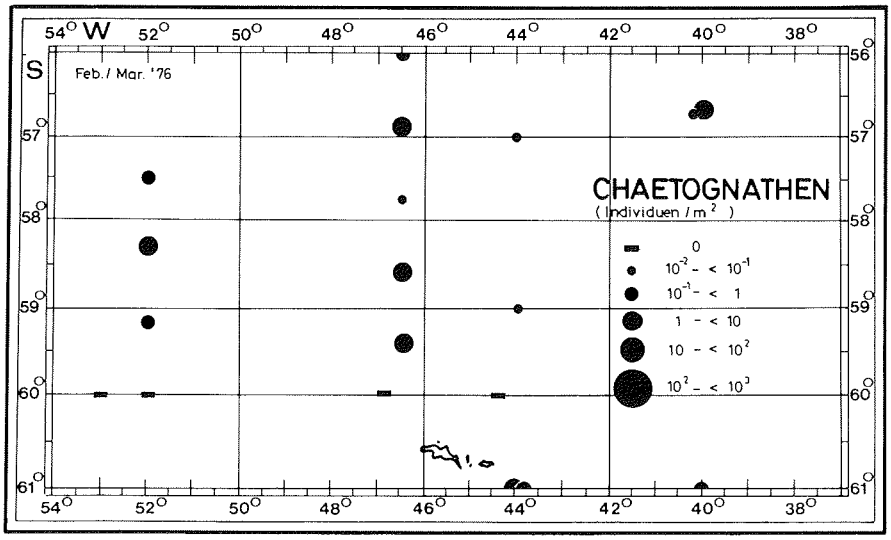

Fig. 51: Geographical distribution and relative abundance of chaetognaths by RMT 8 samples in February/March 1976.

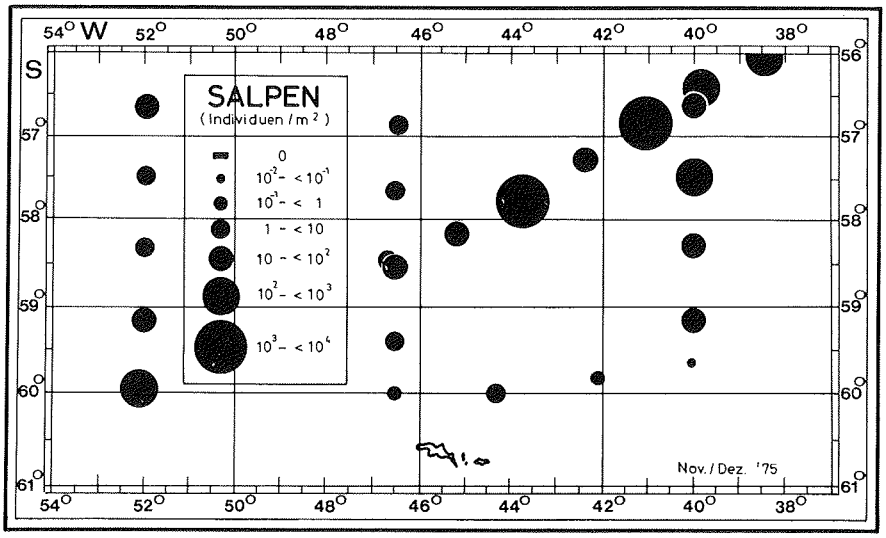

Fig. 52: Geographical distribution and relative abundance of salps by RMT 8 samples in November/December 1975.

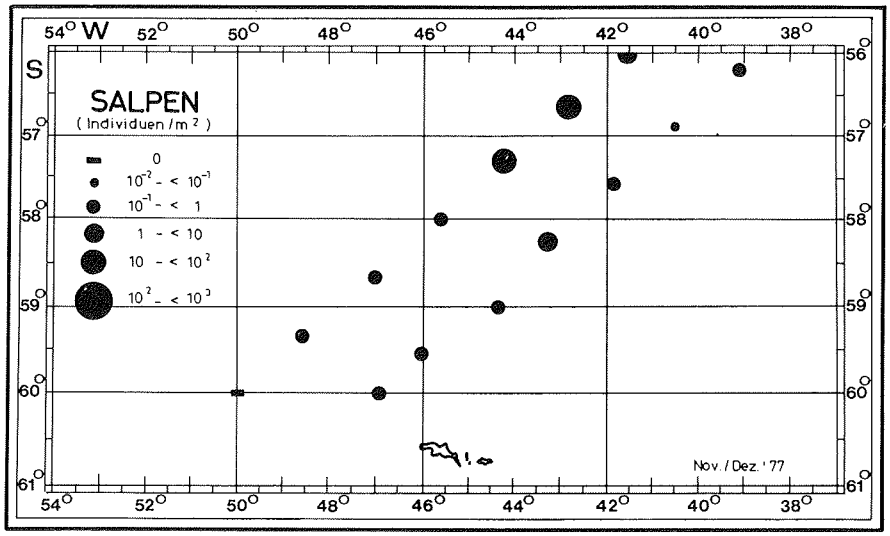

Fig. 53: Geographical distribution and relative abundance of salps by RMT 8 samples in November/December 1977.

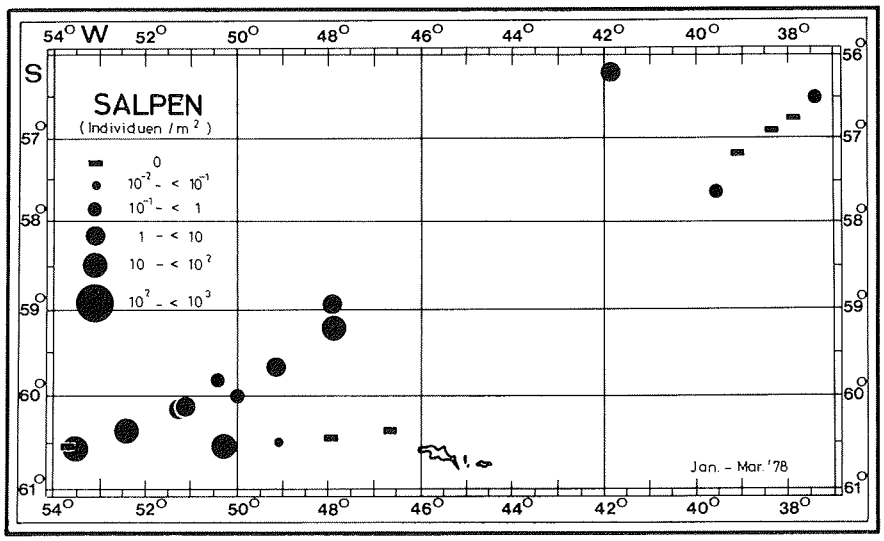

Fig. 54: Geographical distribution and relative abundance of salps by RMT 8 samples from January to March 1978.

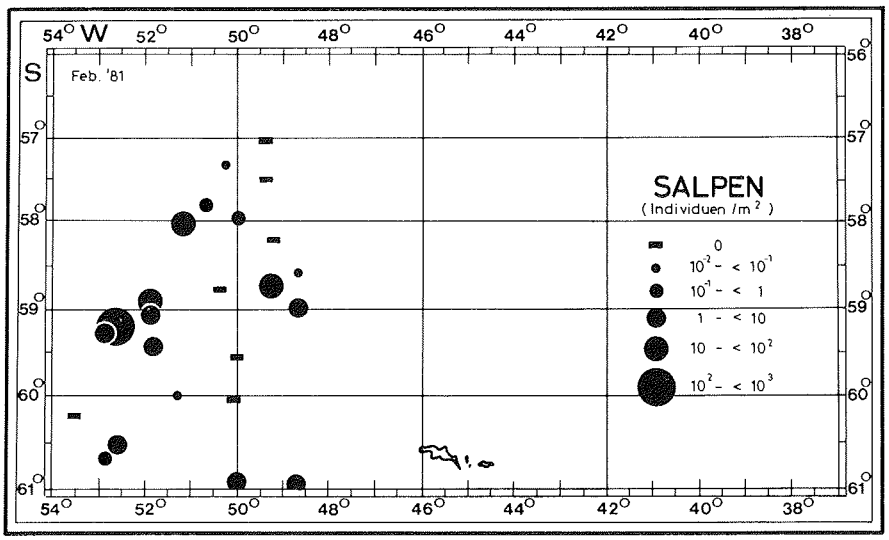

Fig. 55: Geographical distribution and relative abundance of salps by RMT 8 samples in February 1981.

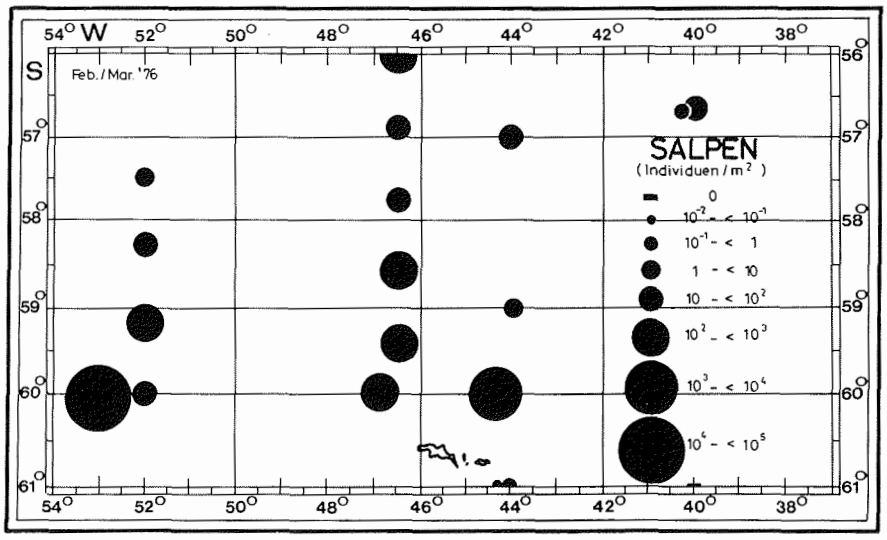

Fig. 56: Geographical distribution and relative abundance of salps by RMT 8 samples in February/March 1976.

South Georgia

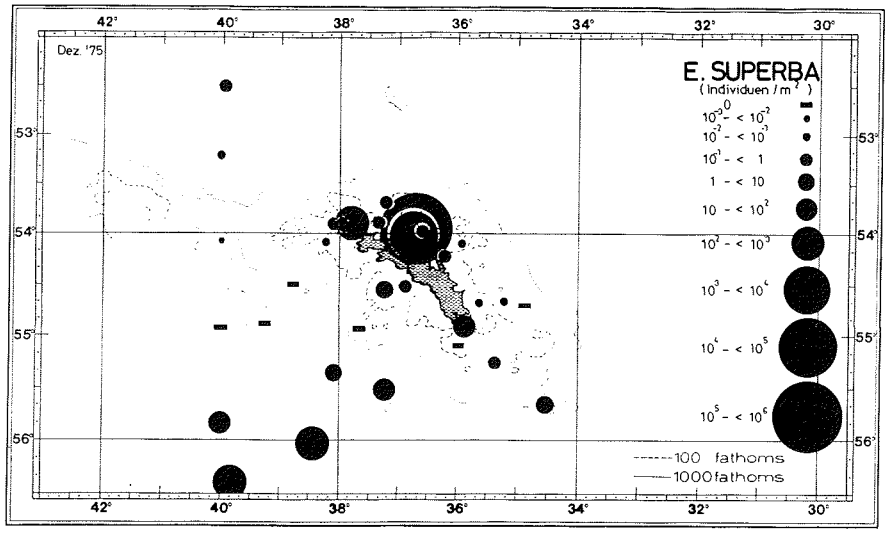

Fig. 57: Geographical distribution and relative abundance of Euphausia superba by RMT 8 samples in December 1975 (modified from Pommeranz 1978).

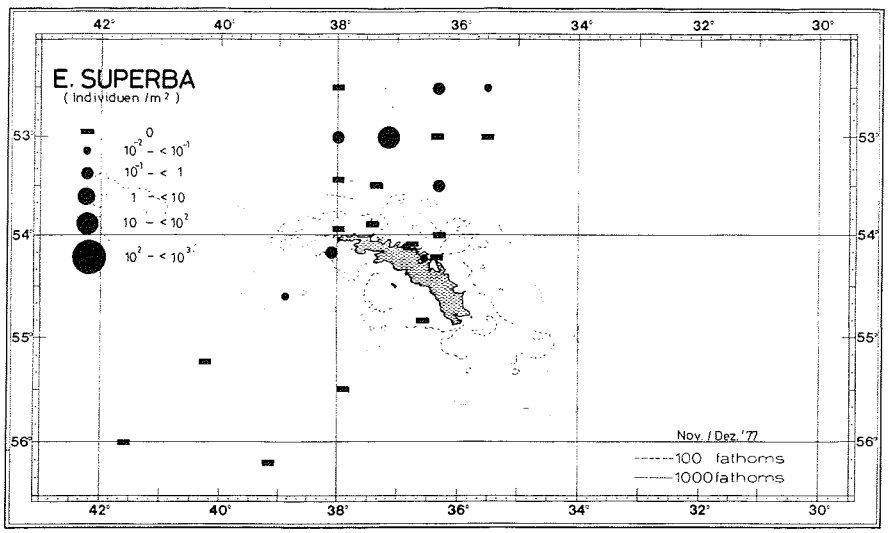

Fig. 58: Geographical distribution and relative abundance of Euphausia superba by RMT 8 samples in November/December 1977 (modified from Wörner 1979).

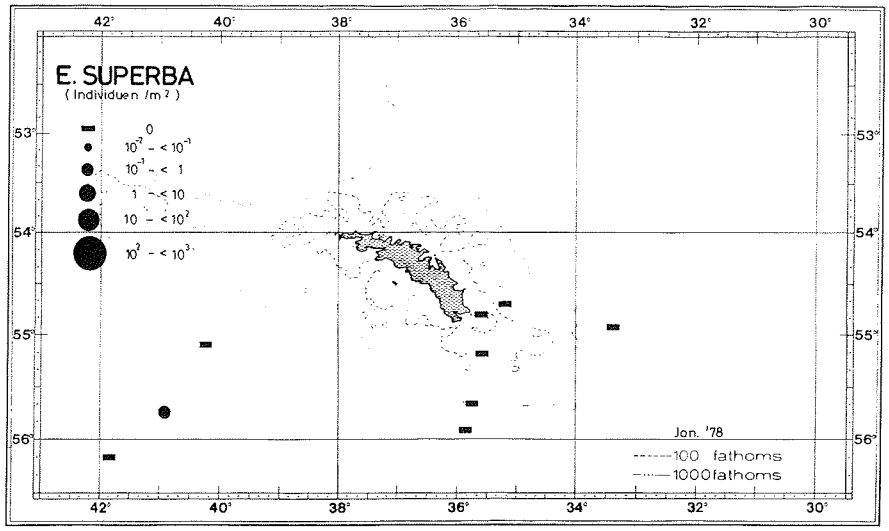

Fig. 59: Geographical distribution and relative abundance of Euphausia superba by RMT 8 samples in January 1978 (modified from Wörner 1979).

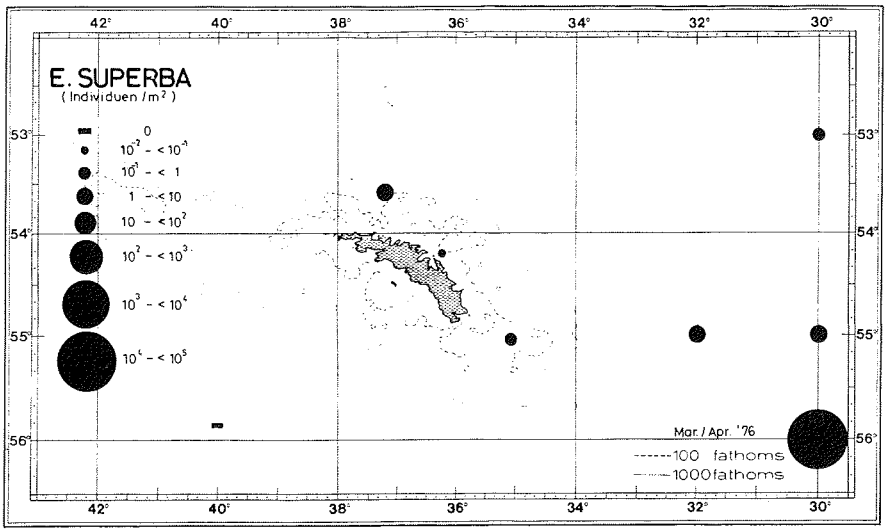

Fig. 60: Geographical distribution and relative abundance of Euphausia superba by RMT 8 samples in March/April 1976 (modified from Pommeranz 1978).

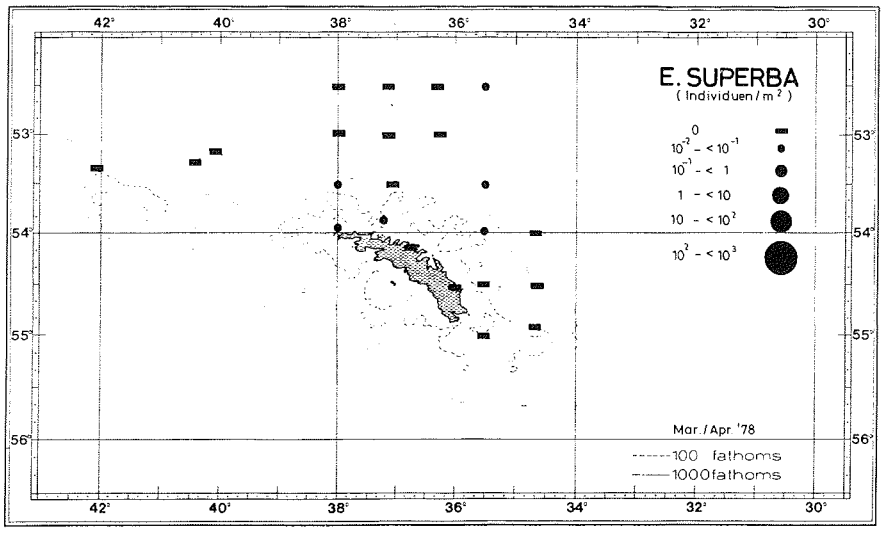

Fig. 61: Geographical distribution and relative abundance of Euphausia superba by RMT 8 samples in March/April 1978 (modified from Wörner 1979).

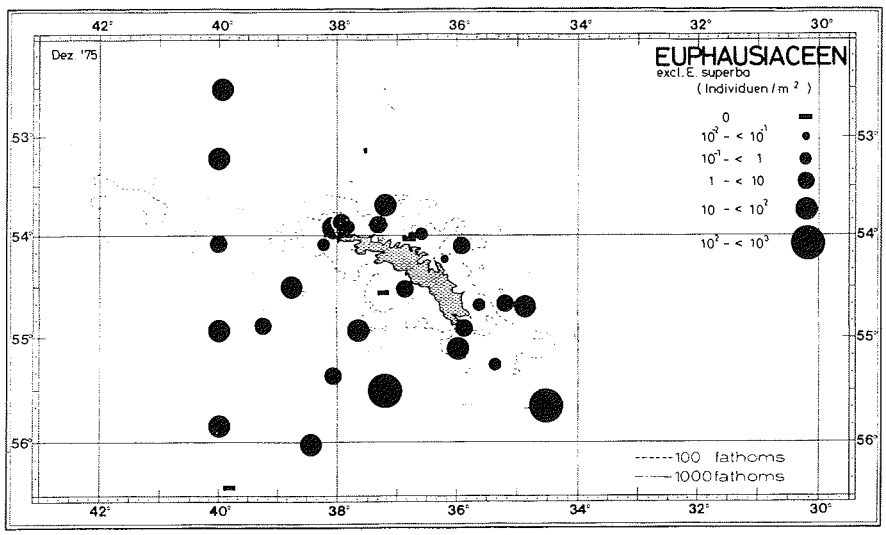

Fig. 62: Geographical distribution and relative abundance of euphausiids (excl. Euphausia superba) by RMT 8 samples in December 1975.

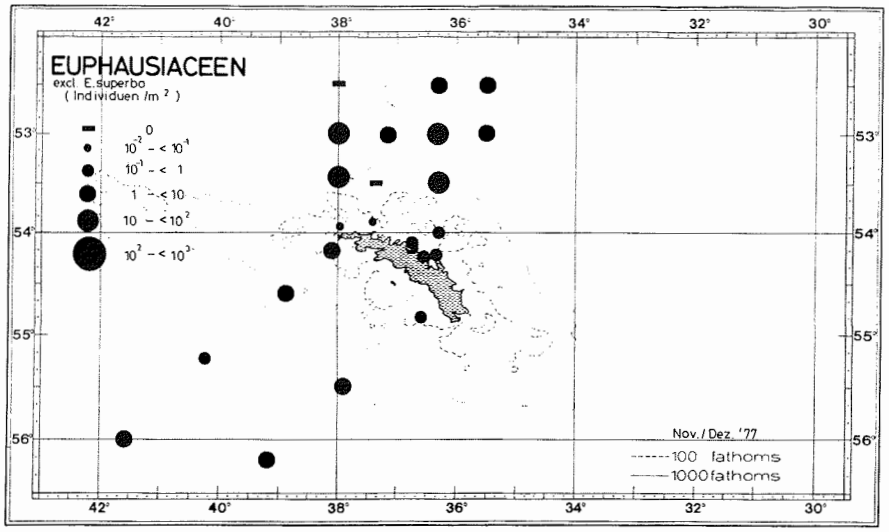

Fig. 63: Geographical distribution and relative abundance of euphausiids (excl. Euphausia superba) by RMT 8 samples in November/December 1977.

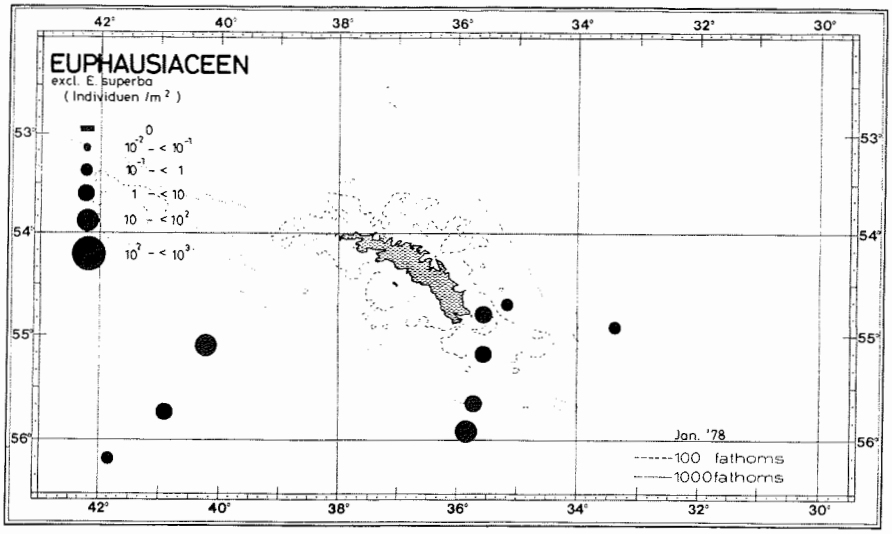

Fig. 64: Geographical distribution and relative abundance of euphausiids (excl. Euphausia superba) by RMT 8 samples in January 1978.

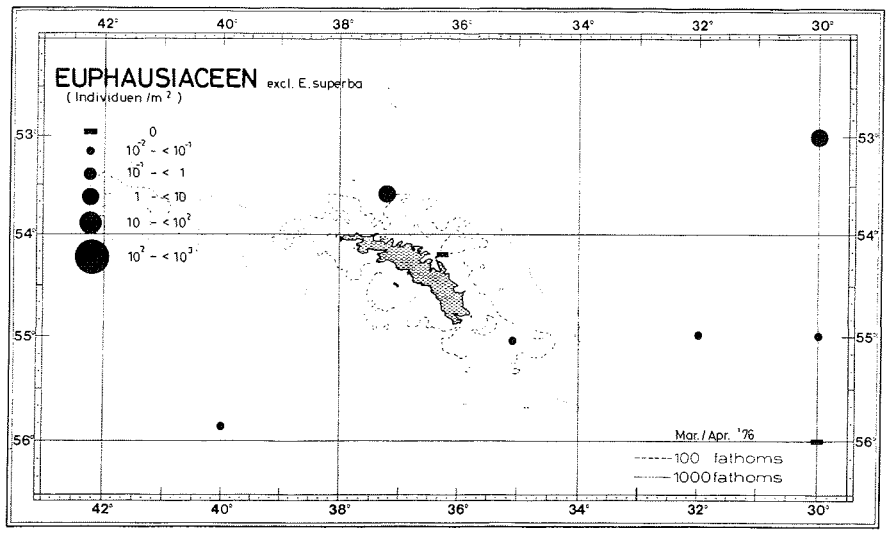

Fig. 65: Geographical distribution and relative abundance of euphausiids (excl. Euphausia superba) by RMT 8 samples in March/April 1976.

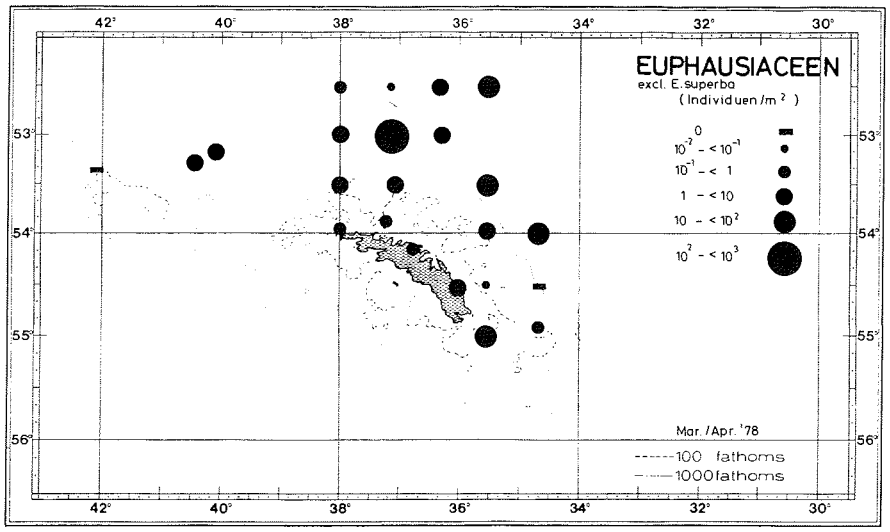

Fig. 66: Geographical distribution and relative abundance of euphausiids (excl. Euphausia superba) by RMT 8 samples in March/April 1978.

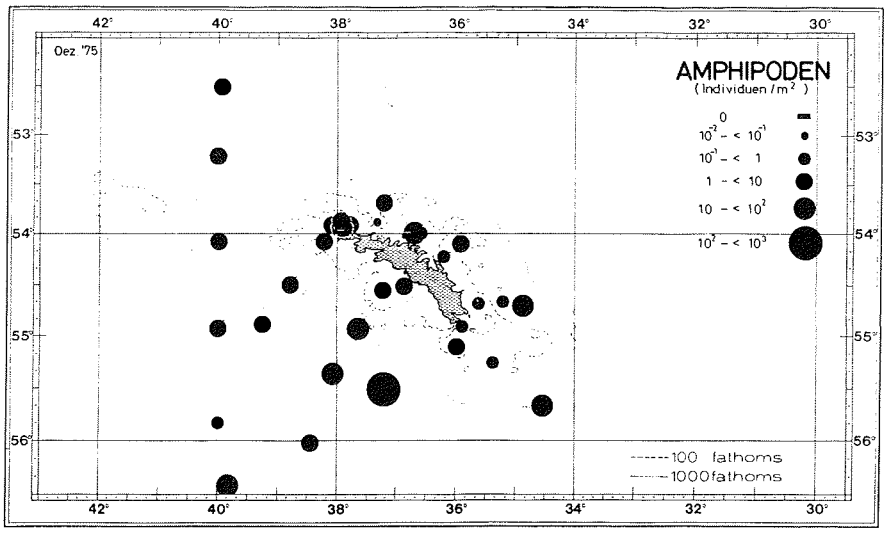

Fig. 67: Geographical distribution and relative abundance of amphipods by RMT 8 samples in December 1975.

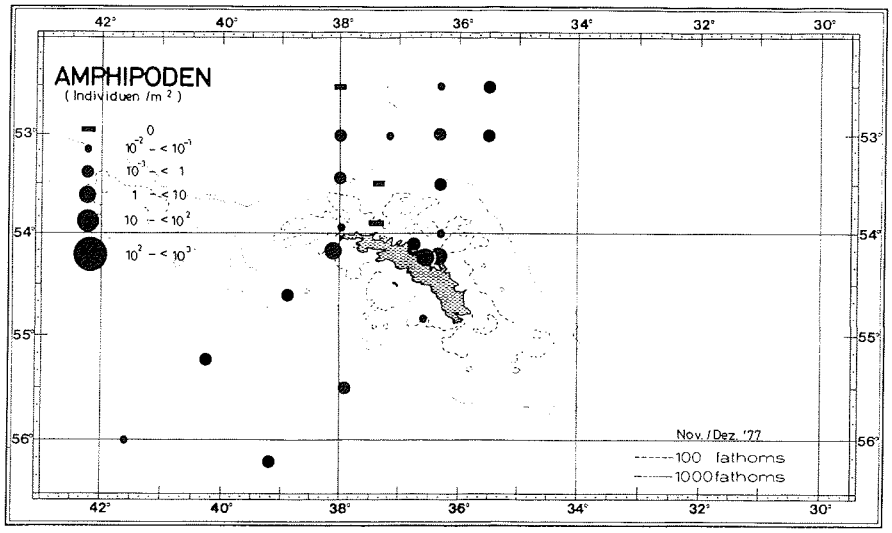

Fig. 68: Geographical distribution and relative abundance of amphipods by RMT 8 samples in November/December 1977.

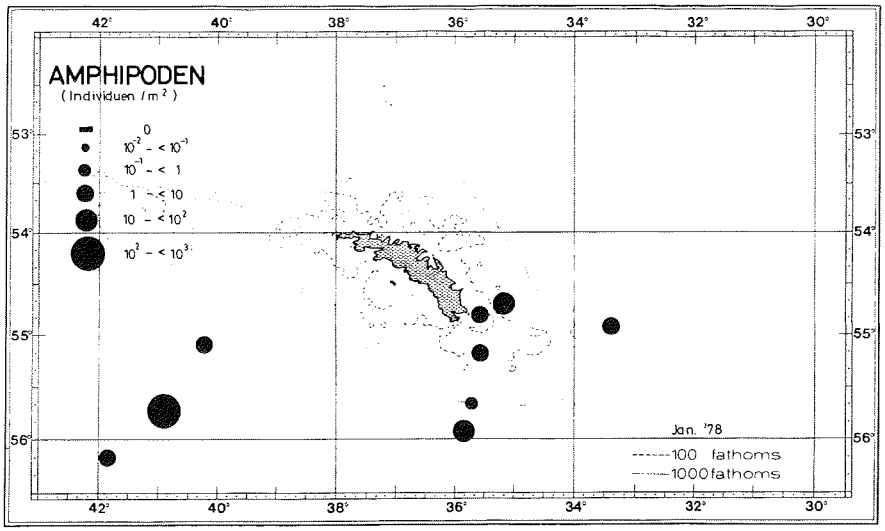

Fig. 69: Geographical distribution and relative abundance of amphipods by RMT 8 samples in January 1978.

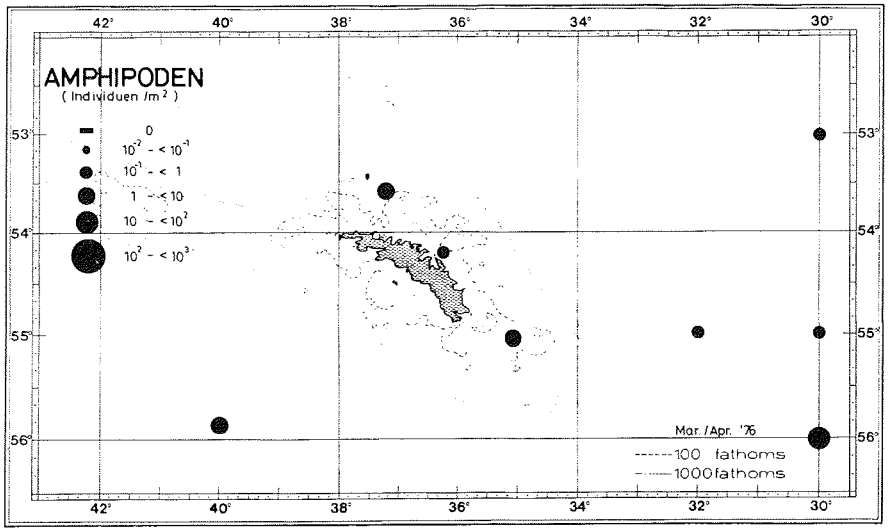

Fig. 70: Geographical distribution and relative abundance of amphipods by RMT 8 samples in March/April 1976.

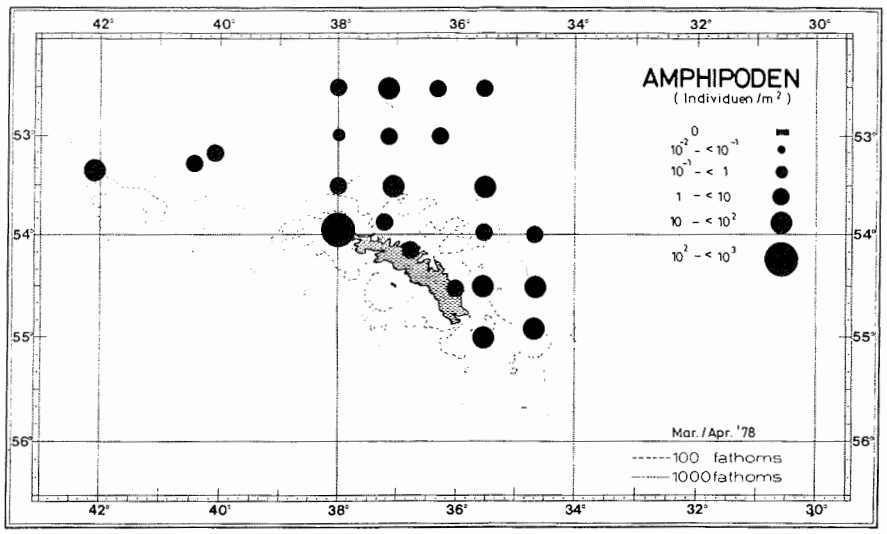

Fig. 71: Geographical distribution and relative abundance of amphipods by RMT 8 samples in March/April 1978.

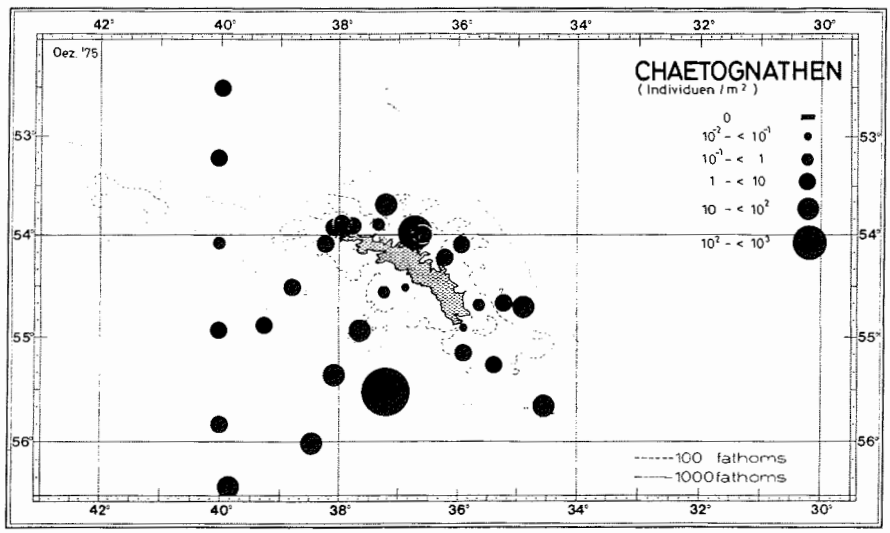

Fig. 72: Geographical distribution and relative abundance of chaetognaths by RMT 8 samples in December 1975.

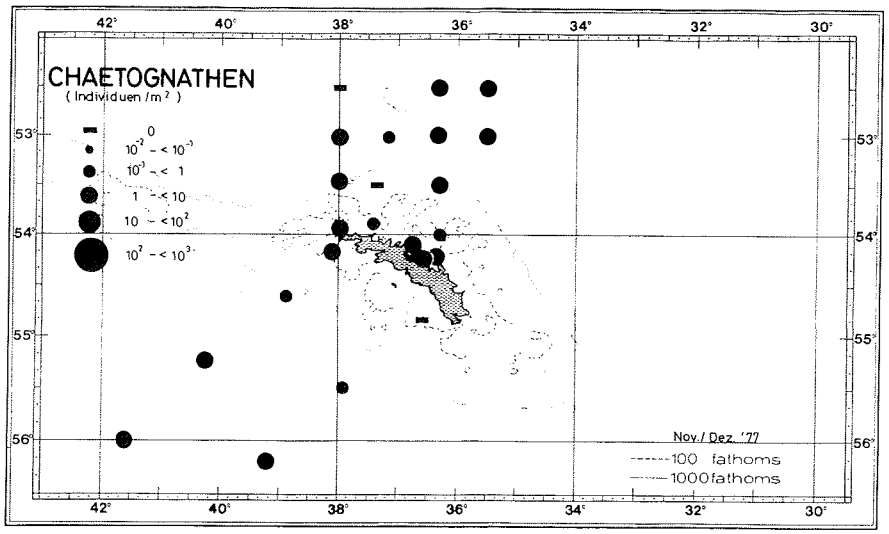

Fig. 73: Geographical distribution and relative abundance of chaetognaths by RMT 8 samples in November/December 1977.

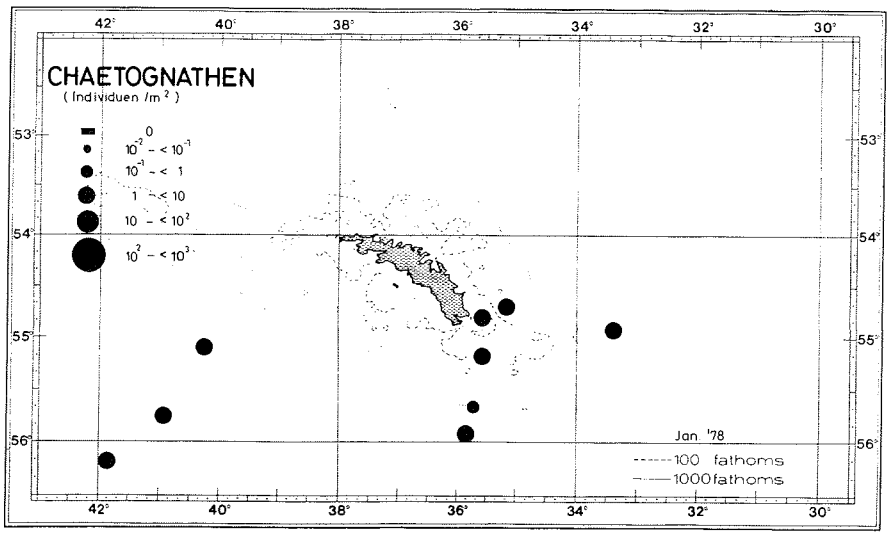

Fig. 74: Geographical distribution and relative abundance of chaetognaths by RMT 8 samples in January 1978.

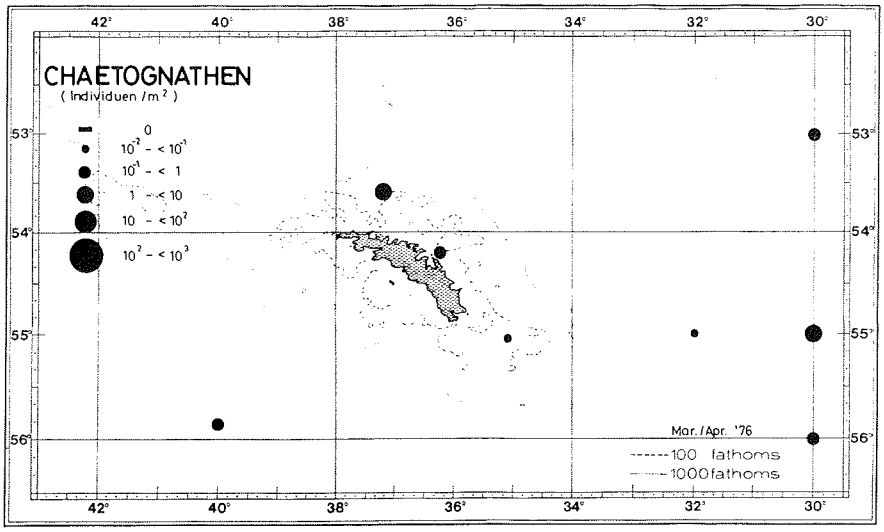

Fig. 75: Geographical distribution and relative abundance of chaetognaths by RMT 8 samples in March/April 1976.

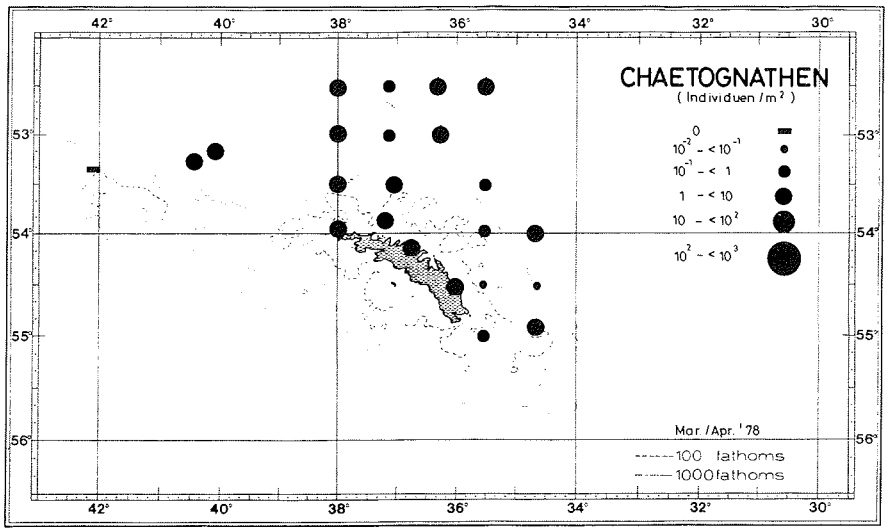

Fig. 76: Geographical distribution and relative abundance of chaetognaths by RMT 8 samples in March/April 1978.

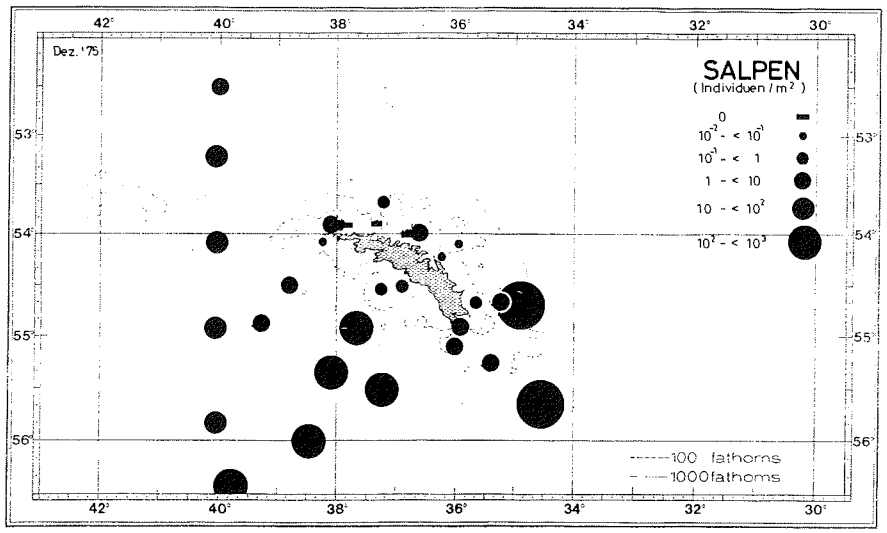

Fig. 77: Geographical distribution and relative abundance of salps by RMT 8 samples in December 1975.

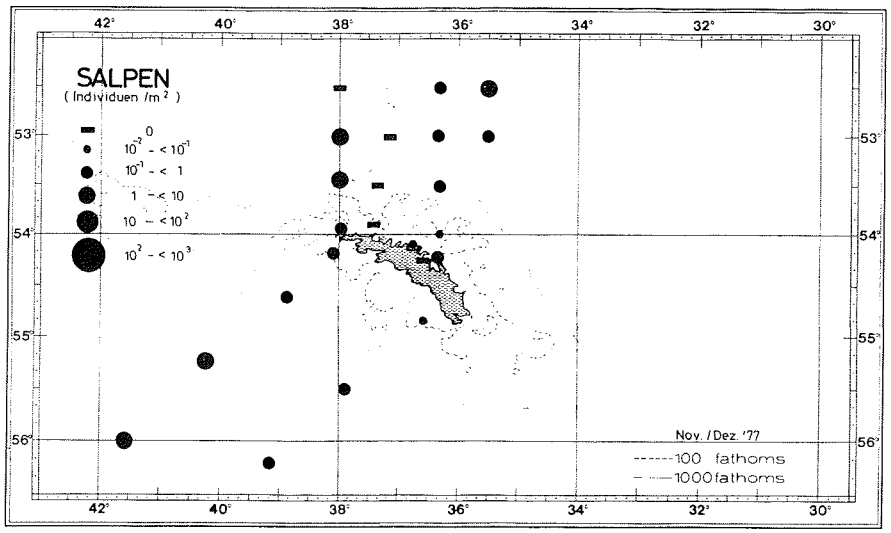

Fig. 78: Geographical distribution and relative abundance of salps by RMT 8 samples in November/December 1977.

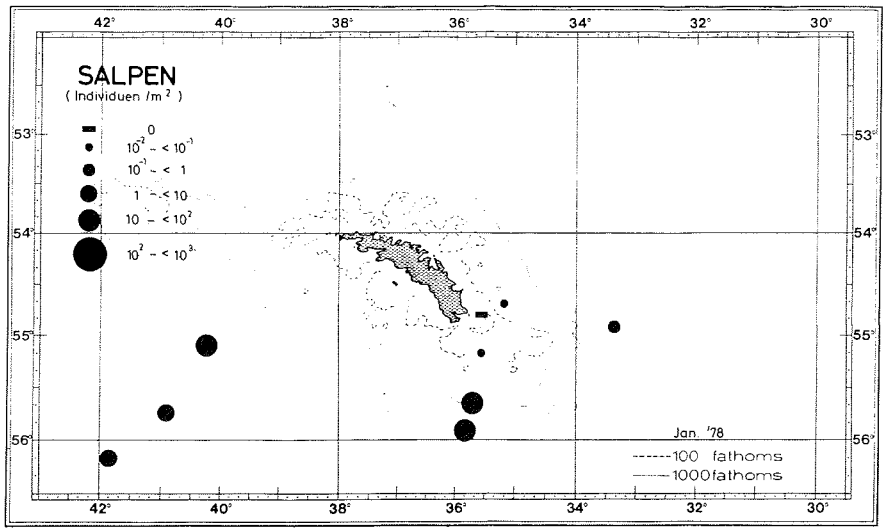

Fig. 79: Geographical distribution and relative abundance of salps by RMT 8 samples in January 1978.

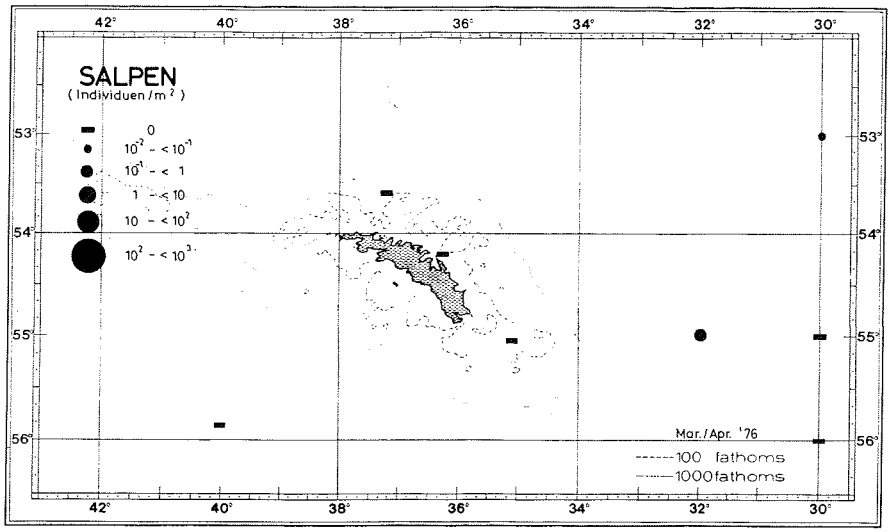

Fig. 80: Geographical distribution and relative abundance of salps by RMT 8 samples in March/April 1976.

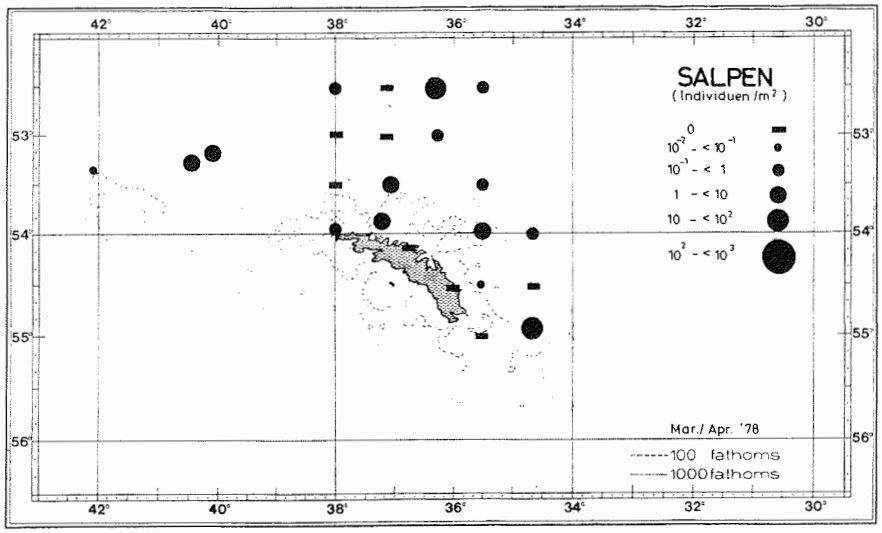

Fig. 81: Geographical distribution and relative abundance of salps by RMT 8 samples in March/April 1978.

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